TERI ENERGY DATA DIRECTORY AND YEARBOOK

TEDDY

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PREFACE

The Tata Energy Research Institute (TERI) is a non-profit research institution engaged in studying and analyzing the country's energy problems. It has been TERI's experience that any meaningful analysis in a specific area entails collection, computation and handling of a large quantity of data and information. Over a period of time, therefore, TERI has collected and compiled an extensive measure of energy and related data from diverse sources.

The recognition of a need to present energy data in a single comprehensive compilation prompted TERI to bring out the first issue of the TERI Energy Data Directory and Yearbook (TEDDY) in 1986. In view of the encouraging response received from energy planners, policy-makers and researchers in the Government, public sector and educational institutions, we intend to make this an annual publication.

The second issue, TEDDY 1987 has a relatively broad data coverage, more data interpretation along with some analytical content, and a presentation of more up-to-date information, due largely to generous assistance and cooperation from the concerned institutions and agencies. It also incorporates several suggestions received for improving upon the first issue. With continued involvement of the energy community in India, and the all-round realization of potential benefits from information sharing, we endeavour to initiate an annual supplement, which would have a deep analytical content on a specific energy problem confronting us on the national energy scene.

The data and other information in this publication have been compiled by Mr. Kapil Thukral and Ms. Preety Malhotra, who received several valuable suggestions and inputs from Mr. A.N. Chaturvedi, Mr. H. Hanagudu, Mr. J. Hossain, Dr. (Mrs.) Veena Joshi, Dr. V.V.N. Kishore, Mr. V. Kothari, Dr. J.D. Pandya, Mrs. C. Puri, Mr. G. Sambasivan and Mr. P.V. Sridharan. Thanks are due also to Mr. C.S. Rawat, Ms. V. Prabha, Mr. M. Jayaraman and Ms. Meenu Ahuja, who have done an excellent job of typing and editing the manuscript.

(R.K. Pachauri)

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I. ENERGY - ECONOMY LINKAGES

I.1 Economic Growth Trends

Total gross domestic product (GDP) has grown from Rs.367.36 billion in 1970/71 to Rs.649.88 billion (1970/71 prices)in 1985/86. This corresponds to a rise in per-capita GDP of over 20% during the sixteen year period, and an annual average growth rate of about 3.9%. Sectoral composition of GDP (at factor cost) has also changed significantly duirng this period, and may be summarized as follows:

(i) the relative share of the primary production sector (including agriculture, forestry, logging, mining and quarrying) reduced from 48% to less than 37%;

(ii) the share of the secondary producing sector (comprising manufacturing industry, construction, and electricity/gas/water supply) showed a distinct though gradual increase from 20% to 22% ;

(iii) there was a marked rise in the share of the transportation, communication and trade sector, from just over 16% to nearly 20% ; and

(iv) there was a substantial increase in the share of the services/commercial sector from less than 15% to over 21%.

These changes at the aggreate sectoral level (Fig.1) were accompained by several compositional changes within each sector. Perhaps the most notable trends include increased mechanization of agriculture and increased cultivation of high yielding variety (HYV) crops; a diversification away from primary and energy-intensive manufacturing industries; a decline in the share of passenger and freight traffic carried by the railways, and so forth. Such trends have resulted in substantial changes in the energy demand mix.

I.2 Energy and Economic Growth

Fig. 2 shows an upward trend in the overall commercial energy consumption intensity in the Indian economy. A gradual increase in the commercial energy intensity in agriculture is also shown (only direct oil and electricity inputs are considered). This reflects the trend towards mechanization of Indian agriculture---both for land preparation and for lift irrigation. Although agriculture is still not a major commercial energy consumer at the national level, it may account for a significant share of commercial energy consumption in certain states, and at least in certain seasons.

The industrial sector continues to be the single largest commercial energy consuming sector, although its share has declined gradually (fig.3). Its commercial energy consumption intensity has also declined over the past decade or more, due largely to a relatively rapid expansion of non-energy intensive indusries. However, the adoption of new (inherently more energy efficient) technologies for certain industrial processes, and the successes at implementing energy conservation measures in certain industrial units, may also be significant factors.

Commercial energy intensity of the transport sector has also increased since the early 1970s. A fall in the share of traffic handled by the railways is the major reason. Goods have been carried over increasingly longer distances in trucks. And for passenger transport, the growth of public modes (buses and mini-buses) has not kept pace with the rise in the more energy intensive mechanized private modes (cars/taxis and 2/3 wheelers). It may be noted that rail and road still continue to account for more than 90% of the total traffic carried.

I.3 Energy Demand and Supply

Although traditional energy fuels (fuelwood, crop-residues and animal wastes) are estimated to account for over 50% of the total final energy consumption in the country, the available data-base is very sparse. It is for this reason alone, that information presented in section 1.2 does not include the use of traditional energy forms.

According to one estimate of non-commercial energy consumption (*), it increased from about 143 million tonnes of oil equivalent (mtoe) in 1972/73 to 161 mtoe in 1982/83. In percentage terms however, its share declined from about 74% to 66% during the ten year period (Fig.4). A large portion of traditional fuels are used rather inefficiently in rural households for cooking, water heating and space heating.

The supply and sales/consumption data for commercial energy forms are relatively well documented. Fig.5 shows the rise in commercial energy consumption since 1970/71. In terms of calorific content, direct use of coal (i.e. excluding coal used for thermal power generation) still accounts for nearly 50% of total commercical energy consumption, and petroleum products for nearly 40%. However, despite the fact that investment (in real terms) in the coal, hydrocarbon and power sectors has nearly quadrupled since 1974/75 (Fig.8), shortages still continue.

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* R. Bhatia, "Energy Demand Management Polcieis in India", the Asian Development Bank, Energy Study Series No.5, 1986.

Owing to persistent shortages of coal and power supplies during the past decade, the consumption of petroleum products . increased more rapidly than was anticipated; the reason being that oil can be imported relatively more easily to help energy shortages in the immediate term. In fact, diesel oils are largely used to mitigate the effects of a power shortage; while fuel oils may be used in industrial boilers in times of a scarcity of coal supplies. It is owing to power shortages and a variety of other reasons (increased use of diesel trucks, dieselization of the railways, a subsidy on kerosene, and so forth), that the share of middle-distillates in the petroleum prdoucts consumption mix has increased (Fig.6).

The power supply utilities have reponded to the power shortage situation by preferring to invest in thermal power stations, whose gestation period is usually less than that of hydro power stations. Consequently, the share of hydro capacity and hydro generation have decreased gradually over the past decade or so (Fig.7). Although coal supplies have increased substantially in recent years (after a period of stagnation during the mid- and late-1970s), shortages still exist. The main reason is that even though with the increase of open-cast mining, coal extraction rates and output per man-shift (OMS) have gone up; the ash content also has. Comparatively larger quantities of coal are now needed to meet a certain requirement, than was the case a decade ago. Therefore, coal transport requirements have increased; and owing to transportation bottlenecks, pit-head stocks have risen while shortages continue to exist in areas away from coal fields.

I.4 Energy Prices

Fig.9 gives the trends of energy prices after the first oil crisis of 1973/74. Energy prices in India are administered, with the goal of pursuing certain social objectives. They do not, in general, reflect costs. The price paths of kerosene and petrol serve to illustrate this point. Kerosene is still subsidized, because it is used in lower income households in rural and urban areas; although it is by now well understood that low income households may not always get the intended benefits. As a result of this subsidy, kerosene demand has increased-- which has led to an increased out flow of foreign exchange on kerosene imports.

Similarly, electricity tariffs are also lower than supply costs -- this is particularly true regarding electricity sales to rural agricultural farmers, for whom the tariffs are lowest (compared to other categories of consumers), while the costs borne by power utilities for supplying them power may well be the highest. These low tariffs have contributed significantly to losses of the state electric utilities.

It is therefore clear that a rational energy pricing policy is very important for the purposes of long term energy planning.

I.5 Energy Balance

Table 1.1 shows a commercial energy balance for 1985/86. Owing to scarcity of reliable data on the supply and consumption of traditional fuels, production, imports/exports, stock changes, conversion losses, net availability and sectoral consumption of only commercial energy is considered. All data are presented in common units of million tonnes of oil equivalent or mtoe (where 1 toe = 10.2 million kcal). The conversion factors for the various energy fuels to mtoe are also shown in Table 1.1. For sake of convenience, all petroleum products are assumed to have the same conversion factor, although there may be some marginal differences.

Of the total availability of 142.6 mtoe of commercial energy in 1985/86, the net availability (and consumption) after conversion is estimated at 101.3 mtoe. About 41 mtoe was lost in conversion processes, mainly for power generation and in crude oil refining. Large quantities of natural gas were also flared.

The final consumption pattern shown in Table 1.1 is based on data available from various sources. Although there may be significant shortcomings in the consumption pattern (such as split for HSD/LDO consumption between agriculture and transport sector), the data presented do highlight some important aspects. For instance, the industrial sector accounted for about 58% of final consumption of commercial energy fuels in 1985/86, and the transport sector for about 21%. However, the transport sector consumed over 44% of total petroleum products for propulsion purposes alone. The agriculture, residential and other sectors do not appear to be major commercial energy consuming sectors. It is important to realize however, that if the role of traditional fuels and draught animal power are also considered, sectoral shares of (total) final energy consumption may change considerably.

Fig. 1: Sectoral Composition of GDP (Rs. billion, 1970-71 prices)

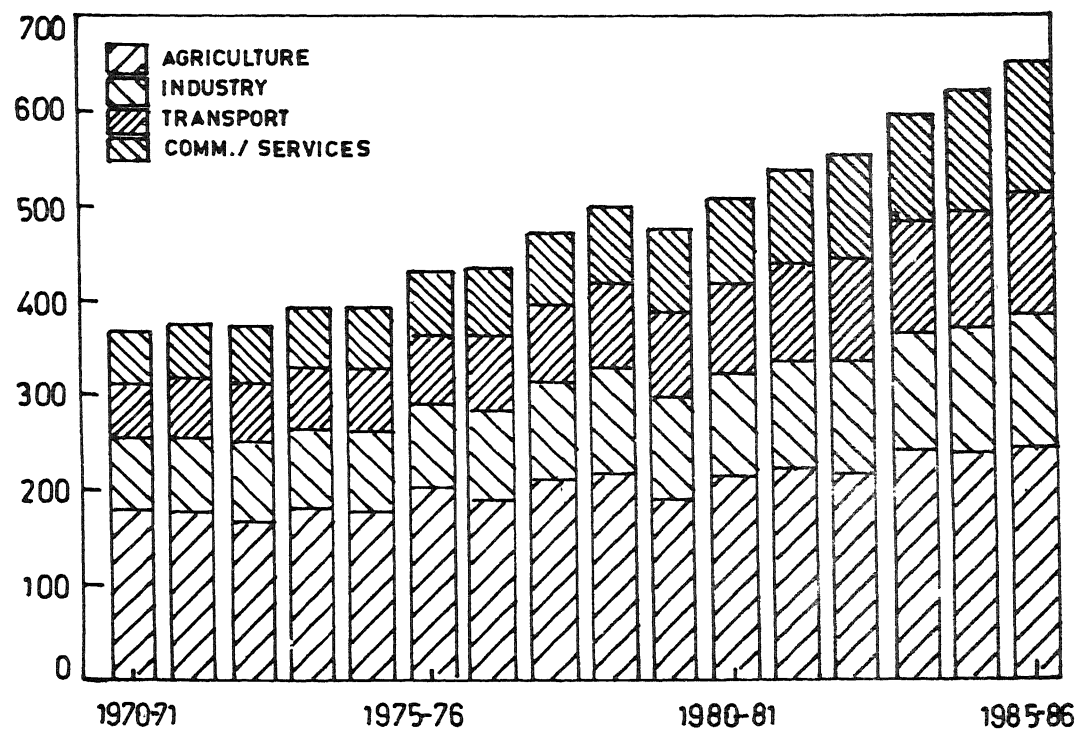

Fig. 2 : Commercial Energy Consumption Intensity (toe per Rs. million, 1975-76 prices)

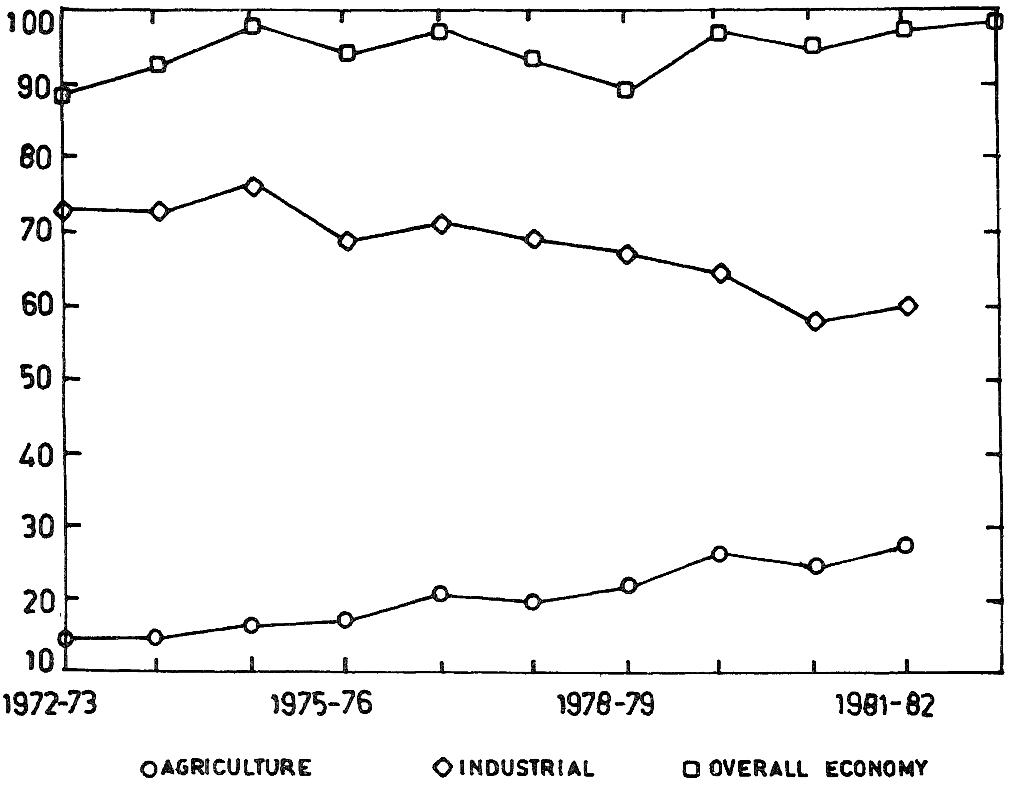

Fig. 3 : Sectoral Consumption of Commercial Energy (million tonnes of Oil Equivalent)

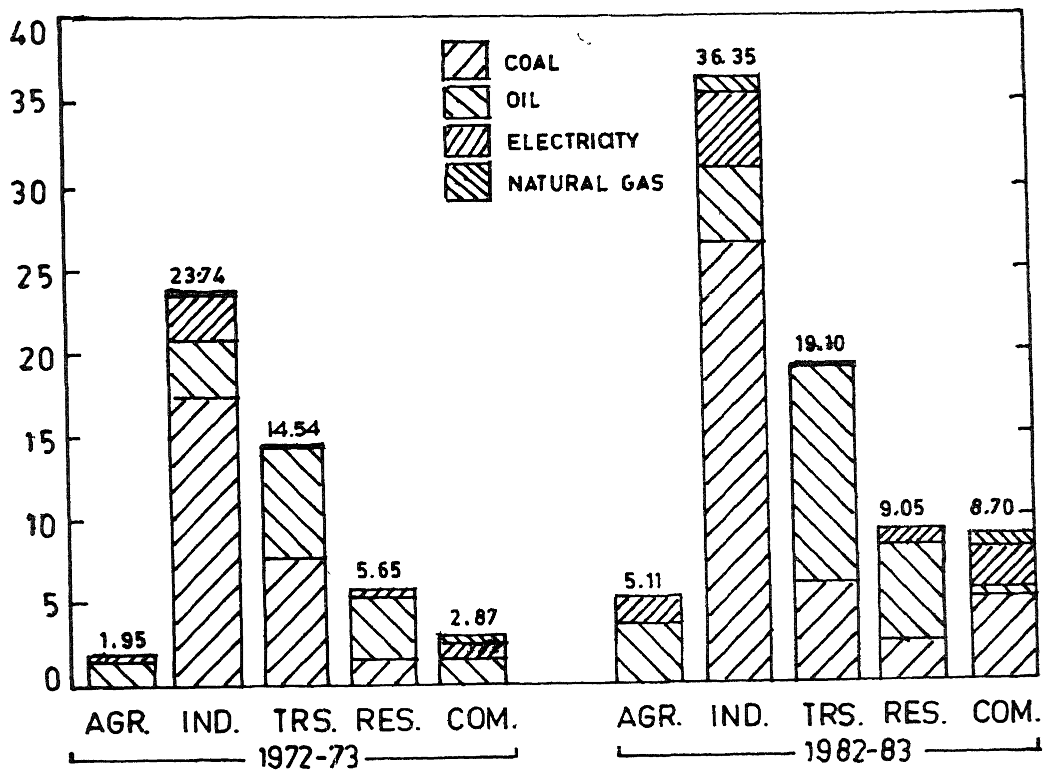

Fig. 4: Trends in Consumption of Commercial and Traditional Energy (million tonnes of Oil Equivalent)

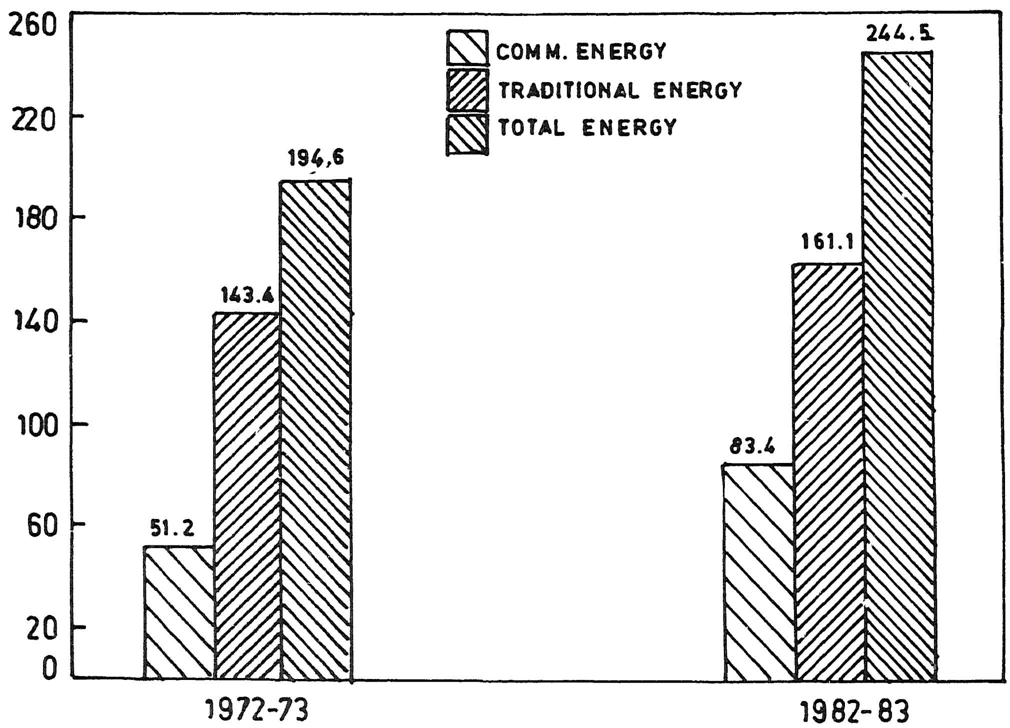

Fig. 5: Total Commercial Energy Consumption (million tonnes of Oil Equivalent)

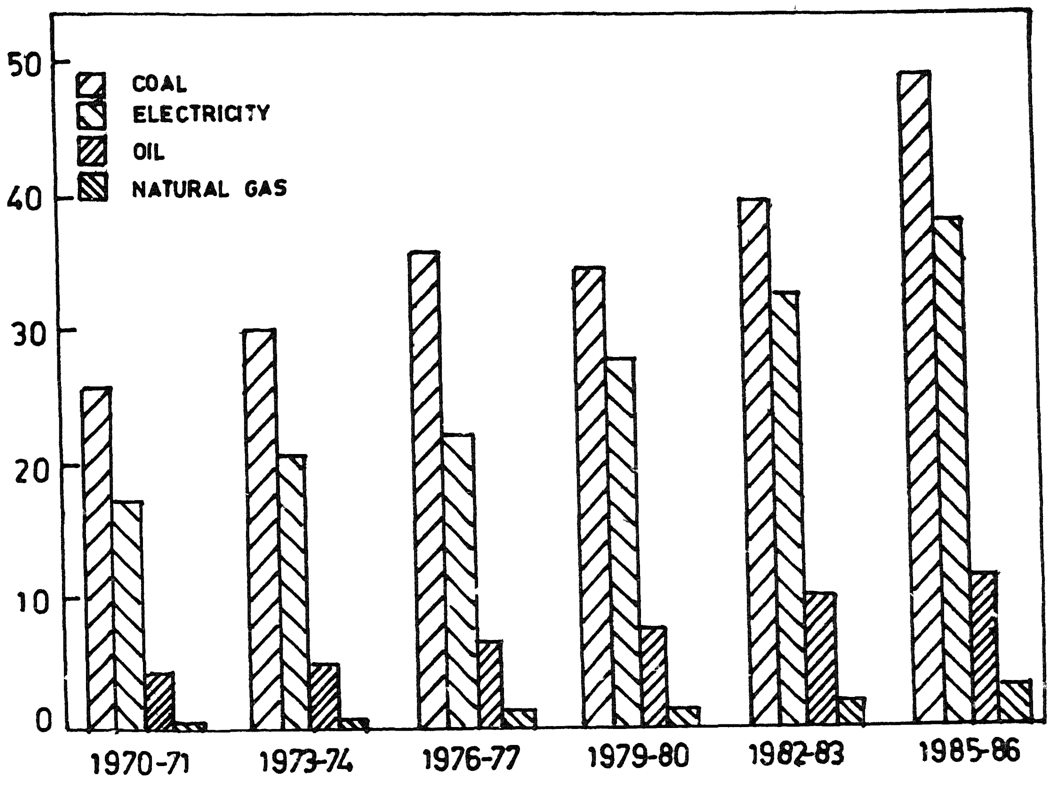

Fig.6 : Trends in Sales of Petroleum Products (%)

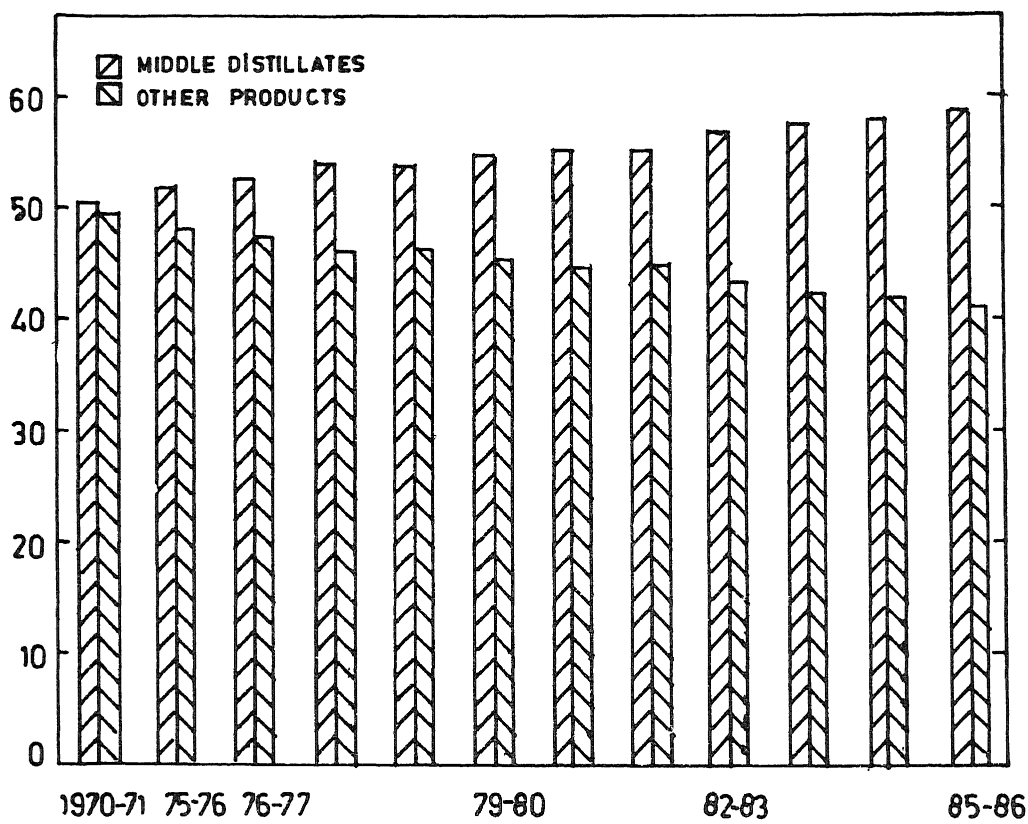

Fig. 7: Share of Hydro-electric Power (%)

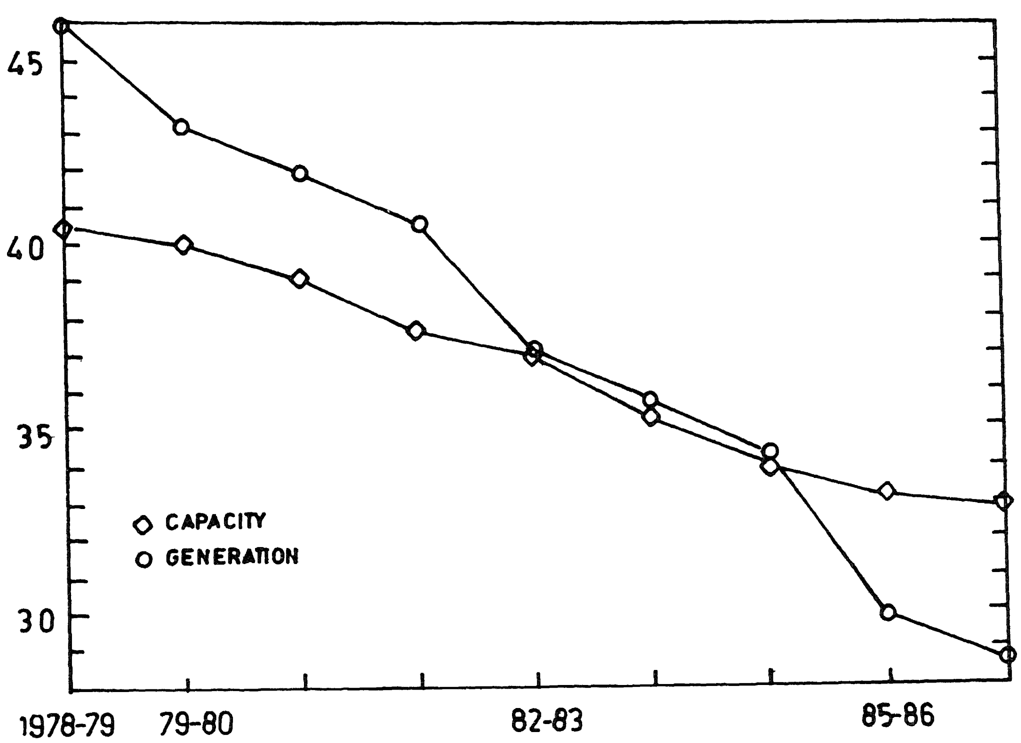

Fig. 8: Investments in Power, Coal and Petroleum Sectors
(Rs. billion, 1979-80 prices)

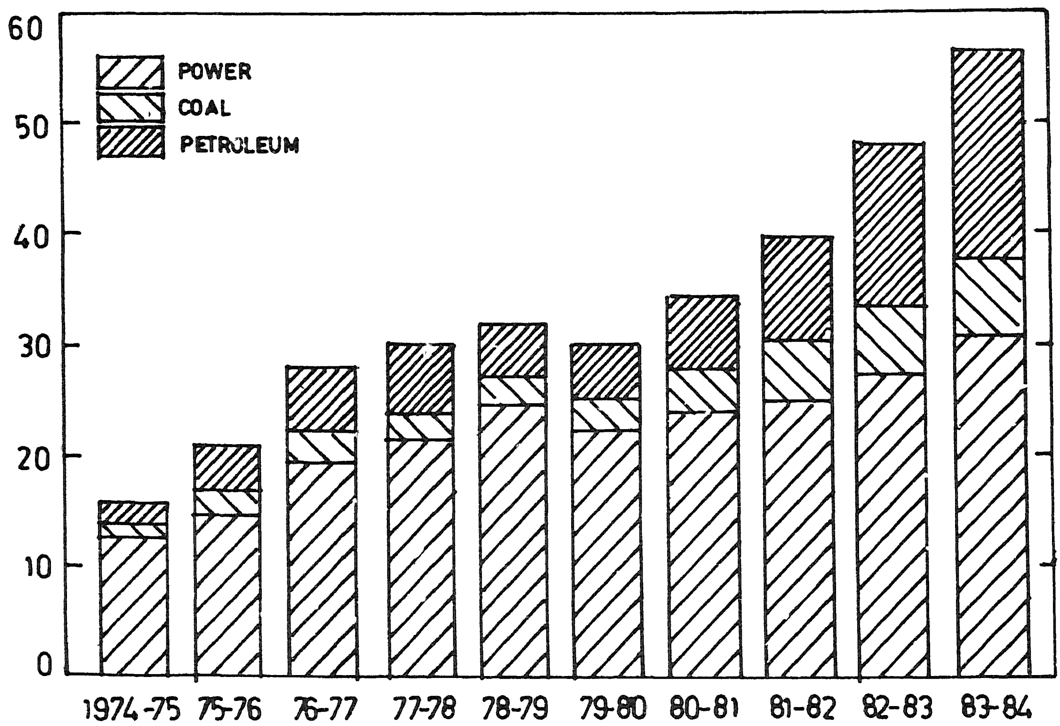

Fig. 9: Indicies of Nominal Energy Prices (1973-74=100)

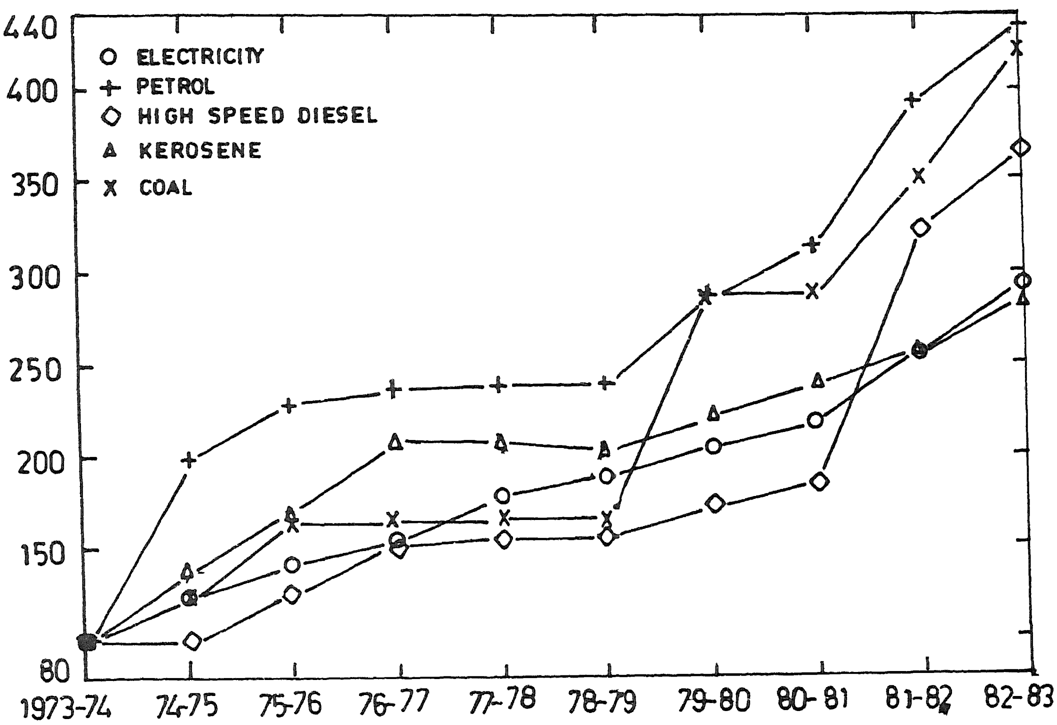

Table I.1 : Commercial Energy

	PRIMARY ENERGY					SEC		
	COAL (a)	CRUDE (b)	NATURAL GAS (c)	HYDRO POWER (d)	NUCLEAR POWER (d)	SOFT COKE	LPG (b)	NAPTHA (b)
A. SUPPLY								
- Production	75.5	30.168	7.343	4.245	0.415	-	-	-
- Imports	0.99	15.144	-	-	-	-	-	-
- Exports	-	0.528	-	-	-	-	-	1.796
- Stock Changes	(-)0.88	1.874	-	-	-	-	0.002	0.031
B. AVAILABILITY	**77.44**	**42.91**	**7.343**	**4.245**	**0.415**	**-**	**(-)0.002**	**(-)1.827**
C. CONVERSION	**(-)29.336**	**(-)42.91**	**(-)4.378**	**(-)0.021**	**(-)0.041**	**1.091**	**1.230**	**4.955**
- Soft Coke	(-)1.146	-	-	-	-	1.091	-	-
- Petroleum Refining	-	(-)42.91	-	-	-	-	0.867	4.955
- LPG Extraction	-	-	(-)0.363	-	-	-	0.363	-
- Power Generation	(-)28.19	-	(-)1.141	-	-	-	-	-
- Conversion Losses	-	3.029	-	-	-	-	-	-
- Aux Cons. in Power Station	-	-	-	(-)0.021	(-)0.041	-	-	-
- T/D Losses	-	-	-	-	-	-	-	-
- Nat Gas Flaring etc.	-	-	(-)2.874	-	-	-	-	-
D. NET AVAILABILITY	**8.104**	**0.0**	**2.965**	**4.224**	**0.374**	**1.091**	**1.228**	**3.128**
E. CONSUMPTION	**48.104**	**0.0**	**2.965**	**-**	**-**	**1.091**	**1.228**	**3.128**
- Agriculture	-	-	0.069	-	-	-	-	-
- Industry	43.645 *	-	0.652	-	-	-	0.115	-
- Transport	4.459	-	-	-	-	-	-	-
- Residential	-	-	0.018	-	-	1.091	1.113	-
- Other Energy Uses	-	-	-	-	-	-	-	-
- Non Energy Uses	-	-	2.226	-	-	-	-	3.128

a. 1MMT = 0.49 mtoe
b. 1MMT = 1 mtoe
c. 1 million cu.m. = 902.8 toe
d. 12000 GWh = 1 mtoe
* Includes coking-coal use, and coal used as feedstock.
@ Excluding T/D losses.

Balance for India (1985/86)
(mtoe)

O N D A R Y   E N E R G Y

MOGAS (b)	ATF (b)	KEROSENE (b)	HSD (b)	LDO (b)	FUEL OILS (b)	OTHER PET PDTS (b)	TOTAL PET PDTS (b)	THERMAL POWER	TOTAL POWER	TOTAL ENERGY
-	-	-	-	-	-	-	-	-	4.66	127.454
-	0.15	2.568	0.89	-	0.02	0.237	3.865	-	-	19.999
-	-	-	0.066	-	0.014	0.087	1.963	-	-	2.491
0.042	0.229	0.398	0.71	0.079	0.248	(-)0.349	1.390	-	-	2.391
(-)0.042	(-)0.079	2.17	0.114	(-)0.079	(-)0.242	0.499	0.512	-	4.66	142.571
2.306	1.519	4.030	14.467	0.924	5.674	2.448	37.553	9.590@	6.449	(-)41.237
-	-	-	-	-	-	-	-	-	-	(-)0.055
2.306	1.519	4.030	14.624	1.177	7.955	2.448	39.881	-	-	(-)3.029
-	-	-	-	-	-	-	0.363	-	-	0.0
-	-	-	(-)0.157	(-)0.253	(-)2.281	-	(-)2.691	32.022	32.022	32.022
-	-	-	-	-	-	-	-	(-)21.401	(-)21.401	(-)21.401
-	-	-	-	-	-	-	-	(-)1.031	(-)1.093	(-)1.093
-	-	-	-	-	-	-	-	-	(-)3.079	(-)3.079
-	-	-	-	-	-	-	-	-	-	(-)2.874
2.264	1.440	6.2	14.581	0.845	5.432	2.947	38.065	9.59@	11.109	101.334
2.264	1.440	6.2	14.581	0.845	5.432	2.947	38.065	-	11.109	101.334
-	-	-	0.145	0.032	0.157	-	0.334	-	1.938	2.341
-	-	-	1.699	0.732	4.984	-	7.53	-	6.441	58.268
2.264	1.440	-	12.737	0.081	0.291	-	16.813	-	0.259	21.531
-	-	6.2	-	-	-	-	7.313	-	1.701	10.123
-	-	-	-	-	-	-	-	-	0.770	0.770
-	-	-	-	-	-	2.947	6.075	-	-	8.301

II. ENERGY SUPPLY

II.1 COAL AND LIGNITE

II.1a Reserves

Coal is the most abundant commercial energy source in India. Coal rsources are assessed on a continuous basis, by the Geological Survey of India, through regional mapping and exploratory drilling. Detailed drilling is done by the Mineral Exploration Corporation, Central Mine Planning and Design Institute to establish proven reserves.

Indian coals are largely of bituminous grade, and an estimated 99.5% of indigenous coal resources are in the Gondwana Basins. A total of about 159 billion tonnes of resources occur up to a depth of about 1200 metres. Of these, about 70% occur in seams of thickness 0.5 metres or more. About 46 billion tonnes of the estimated reserves are actually proven.

Coking and blendable coals amount to less than 18% of the total resources. Coking and superior quality coals are found mostly in the eastern region, mainly in the Jharia and Raniganj coalfields; while the inferior quality coals have a wider distribution. Indian coals usually have a high ash content, except in case of coal seams which are interbanded. The sulphur content however, is very low.

Lignite deposits occur mostly at Neyveli (Tamil Nadu), where about 3.3 billion tonnes of reserves are in the inferred category. These account for about 90% of total lignite reserves in the country. Of these, about 2 billion tonnes fall in the proven category.

Table II.1.1 : Non-Coking Coal Resources (as on April 1, 1986)

State	Depth (metres)	Reserves (MT) Proved	Indicated	Inferred	Total
a. West Bengal	0-300	5424.71	5904.45	890.38	12219.54
	300-600	583.85	4331.16	2278.51	7193.52
	600-1200	156.36	1490.14	4868.06	6514.56
b. Bihar	0-300	7202.85	12375.07	2613.54	22191.46
	300-600	1698.15	4355.42	2430.27	8483.84
	600-1200	-	1038.00	-	1038.00
c. Madhya Pradesh	0-300	7926.44	9175.50	3202.25	20304.19
	300-600	340.43	682.23	1774.42	2797.08
d. Maharashtra	0-300	2052.60	960.10	600.00	3612.70
	300-600	35.50	107.20	1320.00	1462.70
e. Orissa	0-300	3482.58	9389.30	12089.65	24961.53
	300-600	69.38	1547.57	7855.07	9472.02
	600-1200	1.22	28.24	-	29.46
f. Andhra Pradesh	0-300	3148.36	389.90	-	3538.16
	300-600	482.46	1754.14	30.00	2266.60
	600-1200	1.75	37.75	3617.78	3657.28
g. Others	0-300	83.56	193.41	424.47	701.44
	300-600	1.31	70.69	67.81	139.81
h. All	0-300	29321.00	38387.73	19820.29	87529.02
	300-600	3211.08	12848.41	15756.08	31815.57
	600-1200	159.33	2594.13	8485.84	11239.30
	0-1200	32691.41	53830.27	44062.21	130583.89

a. Includes Raniganj, East Barjora, Darjeeling and Deocha Basin coalfields

b. Inlcudes Jharia, East Bokaro, West Bokaro, North Karanpura, South Karanpura, Auranga, Hutar, Daltonganj, Deogarh and Rajmahal coalfields

c. Includes Umaria, Pench-Kanhan, Gurgunda, Sendurgarh, Hasdo-Arand, Singrauli, Bisrampur, Sonhat, Jhilmili, Chirmiri, Sohagpur, Pathakhera, Korba, Johilla, Mand-Raigarh, Lakhanpur, Mohopani and Tatapani-Ramkola coalfields

d. Includes Chanda-Wardha, Kamptee, Umrer, Bander, Nand, Makardhokra and Bokhara coalfields.

e. Includes Ib-River and Talcher coalfields.

f. Includes coalfields in the Godavari valley.

g. Includes Makum, Dilli-Jeypore, Namchik, Nikir Hill, West Daranggiri, Balphakram-Pendenguru, Biju, Languir, Mawlong-Shella Khasi Hills, Barjan and Nagaland coalfields.

Source : Planning Commission.

Table II.1.2 : Coking and Blendable Coal Resources (As on April 1, 1986)

State	Depth (metres)	Reserves (MMT) Proved	Indicated	Inferred	Total
A. Prime Coking Coals					
a. Bihar	0-300	2165.64	155.48	1.72	2322.84
	300-600	1368.82	759.86	287.23	2415.31
	600-1200	89.00	643.04	-	733.04
	0-1200	3623.46	1557.78	288.95	5470.19
B. Medium Coking Coals*					
a. West Bengal	0-300	102.22	48.27	0.32	150.81
	300-600	9.79	80.85	14.86	105.50
	600-1200	0.09	3.90	28.01	32.00
b. Bihar	0-300	5876.53	4077.63	354.33	10308.49
	300-600	2388.30	2978.07	339.00	5705.37
	600-1200	707.22	1894.18	-	2601.40
c. Madhya Pradesh	0-300	155.56	232.11	40.00	427.67
	300-600	48.46	220.83	58.21	327.50
d. All	0-300	6134.31	4358.01	394.65	10886.97
	300-600	2446.55	3279.75	412.07	6138.37
	600-1200	707.31	1898.08	28.01	2633.40
	0-1200	9288.17	9535.84	834.73	19658.74
C. Blendable Coals					
a. West Bengal	0-300	338.54	133.02	3.59	475.15
	300-600	100.84	440.63	48.69	590.16
	600-1200	76.31	240.88	555.73	872.92
b. Bihar	0-300	216.51	174.79	23.52	414.82
	300-600	53.50	282.72	52.90	389.12
	600-1200	0.42	4.13	5.06	9.61
c. All	0-300	555.05	307.81	27.11	889.97
	300-600	154.34	723.35	101.59	979.28
	600-1200	76.73	245.01	560.79	882.53
	0-1200	786.12	1276.17	689.49	2751.78

* Includes semi and weakly-coking coals.
a. Includes Raniganj coalfields.
b. Includes Jharia, East Bokaro, West Bokaro, North Karanpura and South Karanpura coalfields.
c. Includes Pench-Kanhan, Sonhat and Sohagpur coalfields.

Source : Planning Commission.

II.1b Coal and Lignite Production

Following a period of stagnation in the latter half of the 1970s, coal production increased rapidly after 1979/80. From about 103 million tonnes (MMT), in 1979/80, it rose to about 163 MMT in 1986/87. Coal India Limited (CIL), the premier coal producer in the country, contributed over 85% of the total production.

An integrated development programme for the coal industry was initiated after its nationalization in 1973. Reorganization/reconstruction of existing mines was a major activity initiated during the 1970s, along with a programme of an optimal selection of new technologies, standardization of equipment, and infrastructure development. New mining techniques were also introduced, as opencast mining increased.

Larger and more powerful equipment (shovels, draglines, dumpers etc.) are now being deployed to permit opencast mining up to a depth of as much as 500 metres. In the underground mines, which are being planned for exploiting deeper deposits, the approach now is towards a shift from the semi-mechanized bord and pillar method (which results in high mining losses and low productivity, with a high cost of production) to mechanized bord and pillar operations, and progressive expansion to longwall methods of mining.

With these measures, the output per man-shift (OMS) is anticipated to rise to about 1 tonne by 1989/90 and furtheron to 2 tonnes by 1999/2000. For opencast mines alone, the OMS is expected to reach the 4 tonne mark by the turn of the century. Although these targets for OMS are considerably higher than the present levels, they are still short of what some of the other major coal producing countries have achieved -- a part of this difference however, may arise from the fact that only manpower that is employed directly for coal mining operations is considered for computing the OMS in other countries, while in India, indirect employment is also considered.

Coal stocks at pit-heads usually decline during the months April to October every year, when coal proudction is low (due to various reasons, including monsoon rains, power shortages, absenteeism of workers etc.). However, there is a distinct trend towards rising pit-head stocks since 1979/80. This may reflect the fact that transportation bottlenecks continue to exist -- despite the fact that the railways have increased coal haulage considerably since 1980.

The lignite reserves at Neyveli are exploited by the Neyveli Lignite Corporation (NLC). NLC operates two mines, one of a capacity of 6.5 million tonnes per annum (mtpa), and the other of 4.7 mtpa. The second mine is now being expanded to a 10.5 mtpa capacity.

Table II.1.3 : Production, Despatches and Closing Stock of Coal -- All India (million tonnes)

		1975/76	1977/78	1979/80	1981/82	1983/84	1985/86
a.	Production (total)	99.68	100.97	103.95	124.23	138.24	154.24
a1	Coking	22.19	23.31	23.50	30.25	35.98	35.65
a2	Non-Coking	77.49	77.66	80.45	93.98	102.26	118.59
b.	Despatches (total)	91.96	99.50	99.58	118.10	130.27	150.84
b1	Coking	21.16	22.85	21.33	24.54	34.85	34.34
b2	Non-Coking	70.80	76.65	78.25	93.56	95.42	116.35
b3	From CIL* (total)	77.96	84.72	84.23	103.34	114.66	134.11
	- by rail	59.81	63.02	54.83	69.78	N.A.	N.A.
	- by road	13.38	16.36	23.33	26.61	N.A.	N.A.
	- by other means	4.77	5.34	6.07	6.95	N.A.	N.A.
b4	From other Coal Companies**	14.00	14.78	15.35	14.76	15.61	N.A.
c.	Closing Stocks at the end of Year (total)	11.84	12.18	14.01	21.25	22.89	28.82
c1	Coking	1.67	2.24	3.94	9.07	7.10	9.9
c2	Non-Coking	10.17	9.94	10.07	12.18	15.79	18.92

* Coal India Ltd. (CIL), includes Eastern Coalfields Ltd. (ECL), Bharat Coking Coal Ltd. (BCCL), Central Coalfields Ltd. (CCL), Western Coalfields Ltd.(WCL) and North-Eastern Coalfields Ltd. (NECL).

** Includes Singareni Collieries Company Ltd. (SCCL), Tata Iron and Steel Company Ltd. (TISCO), Damodar Valley Corporation (DVC) and coalfields in Jammu and Kashmir

Source : (i) Coal Controllers' Organization, All India Annual Coal Statistics 1983/84, GOI, Calcutta; and (ii) Centre for Monitoring Indian Economy (CMIE), Current Energy Scene in India, Bombay, May 1987.

Table II.1.4 : Lignite Statistics
(MMT)

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
a. Production (total)	6.306	6.932	7.297	7.72	8.04	9.63
a1 Tamil Nadu	5.876	6.401	6.679	7.10	7.24	8.55
a2 Gujarat	0.430	0.531	0.618	0.62	0.80	1.08
b. Despatches	6.295	6.980	7.241	7.24	7.675	N.A.
b1 Tamil Nadu	5.865	6.449	6.623	6.62	6.869	N.A.
b2 Gujarat	0.430	0.531	0.618	0.62	0.806	1.08
c. Stocks at end of year (total)	0.120	0.072	0.079	0.48	0.216	N.A.
c1 Tamil Nadu	0.120	0.072	0.079	0.48	0.216	N.A.
c2 Gujarat						

Source : (i) Coal Controllers' Organization, op cit Ref. Table II.1.3; (ii) Coal Controllers' Organization, Monthly Coal Statistics, March 1986, GOI, Calcutta; and (iii) Centre for Monitoring Indian Economy, (CMIE), Basic Statistics Relating to the Indian Economy, Vol.2 : States, Bombay, September 1986.

Table II.1.5 : Share of Open Cast Coal Production

	Total Production (MMT)	Production from Open Cast Mines (MMT)	Share of prod. from OC mines (%)
1960/61	55.67	10.86	19.5
1970/71	72.95	14.68	20.1
1980/81	114.00	41.15	36.1
1982/83	130.60	55.76	42.7
1984/85	147.40	74.00	50.2
1985/86	154.30	77.90	50.4
1986/87	165.76	89.24	53.8

Source : (i) R.G. Mahendru, Indian Energy Perspective - Coal, Presented at the 12th Congress of the World Energy Conference, New Delhi, September 1983; (ii) Planning Commission; and (iii) Personal Communication, Department of Coal, GOI, New Delhi.

Table II.1.6 : Trends in Coal Mining

	Operating (as in 1983)	Planned
A. Open Cast Mining		
Coal Production (MMT/year)	=< 3	10-14
Overburden (million cu.m./year)	=< 6	40-55
Average Stripping Ratio (cu.m./tonne)	=< 2	3-7
Depth (metres)	100-120	Upto 430
OMS (tonnes)	1.8	Upto 10
Electric Power Cons. (kWh/tonne)	3-4	8-10
Size of Rope Shovels (cu.m.)	Upto 10	12.5, 20
Size of hydraulic Shovels (cu.m.)	0.9-3	4-10
Size of Rear Dumpers (tonnes)	25,35,50	85,120,170
Size of Coal Haulers (tonnes)	=< 50	100,120
Size of Draglines (cu.m.)	4-34	24-32
Size of Drills (mm)	=<250	311
B. Underground Mining		
Size of mine (MMT/year)	0.5-0.8	2-3.5
Depth (metres)	100-400	250-700
OMS (tonnes)	0.55	2-3
Electric Power Cons. (kWh/tonne)	10-15	25-30
Face of operating voltage (volts)	550	1100

Source : Mahendru (1983), op cit Ref. Table II.1.5.

Table II.1.7 : An International Comparison of Trends in Output per Manshift (OMS)*

	India	Australia**	USA	W.Germany	Japan	France
1956	0.39	3.79	8.67	0.95	0.50	0.98
1961	0.46	6.76	11.73	1.33	0.71	1.15
1966	0.56	9.12	16.06	1.67	1.18	1.31
1971	0.67	9.91	15.90	2.25	1.74	1.52
1976	0.69	11.85	11.49	2.44	1.82	1.56
1981	0.81	12.59	12.88	2.92	2.03	1.94
1984	0.90	16.40	16.30	3.11	2.12	1.94

* For India, the manshift considered for calculating OMS includes work by all personnel engaged in mining operations, administrative/managerial and other services of the coal companies, as well as by manpower engaged in social activities (such as schools, water supply, post and telegraph etc.) in mining townships. In other countries however, work done by manpower not employed directly by the coal mining company is not considered while computing OMS.

** For New South Wales only.

Source : Planning Commission.

II.1c Quality of Indian Coals

The basic property of coal as a fuel, is its heat potential, or its calorific content. Other physical and chemical characteristics, particularly ash and moisture content are also important properties. Sulphur content of Indian coals is usually low.

Indian coals have a high ash content. Ash comprises residual non-combustible matter that comes from silt, clay, silica etc., which may have contaminated coal at the time of deposition and formation. The heating value of coal reduces with increase in ash, because some heat is required to melt it -- this may be a significant fraction of the total gross calorific value (GCV) of coal if the ash content is high. It is for this reason that a useful heating value (UHV) is specified for Indian coals, in place of GCV. The difference between GCV and UHV increases with an increase in ash content.

The following formula is a convenient way to estimate UHV if the ash and moisture contents are known :

UHV (kcal/kg) = 8900 - 138 (% Ash + % Moisture)

The moisture content of non-coking coals is also usually high (ie, >= 2%). Coking coals however, have moisture content of less than 2%.

The grading of coking coals is basically related to the % ash content; while that of non-coking coals is based on UHV. This difference in the grading criteria arises largely because the moisture content of coking coals is low.

Over the past decade or so, the average calorific content of both coking and non-coking coals has declined. This may be due to an increase in production from mechanized open-cast mines, which leads to significant proportions of free dirt, boulders, and other lumpy, extraneous matter along with coal. Even from 1983/84 to 1986/87, the share of Steel Grades I and II coking coals in total coking coals mined by CIL, has reduced from 9.6% to 3.8%. Similarly, the share of Grade A,B,C non-cokig coals to total non-coking coal mined by CIL, has also declined from 58.5% to 46.4% during the same four year period.

Table II.1.8 : Grading of Coking Coals

A. Prime and Medium Coking Coals

Grade	**Ash Content %**
Steel Grade I (S-I)	=< 15
Steel Grade I (S-II)	15-18
-	18-19
Washery Grade I (W-I)	19-20
Wahsery Grade II (W-II)	20-24
Washery Grade III (W-III)	24-28
Washery Grade IV (W-IV)	28-35

B. Semi-Coking and Weakly Coking Coals

Grade	**Ash plus Moisture Content %**
Semi-Coking I (SC-I)	=< 19
Semi-Coking II (SC-II)	19-24

Table II.1.9 : Grading of Non-Coking Coals

Grade	Ash+Moisture content (%)	Useful Heating Value (kcal/kg)	Median Gross Calorific Value (kcal/kg)
A	=< 17	> 6200	6300
B	17-19	5600-6200	6100
C	19-24	4940-5600	5700
D	24-32	4200-4940	5200
E	32-35	3360-4200	4700
F	> 35	2400-3360	4000
G	> 35	1300-2400	3300

Table II.1.10 : Relationship Between Gross Calorific Value (GCV) and Useful Heat Value (UHV)

Ash Content (%)	GCV-UHV (Kcal/kg)
2	20
4	50
6	80
8	105
10	145
12	200
14	240
16	300
18	380
20	480
22	600
24	720
26	860
28	960
30	1030
32	1090
34	1165
36	1240
38	1300
40	1370
42	1440
44	1500
46	1575
48	1650
50	1710

Table 11.1.11 : Grade-Wise Production of Coal (MMT)

Grade	1983/84 Total	CIL	1985/86 CIL	1986/87 CIL
A. Coking Coals				
S I	0.336	0.336	0.025	0.028
S II	2.958	2.738	1.317	1.298
W I	2.249	1.637	2.407	2.310
W II	9.228	8.376	13.783	13.947
W III	12.056	11.197	3.966	4.613
W IV	8.400	6.959	8.010	10.499
S/C I	0.756	0.756	0.343	0.359
S/C II	-	-	0.180	0.201
Sub-Total*	35.983	31.999	30.571	34.453
B. Non Coking Coals				
A	4.390	4.390	4.057	3.808
B	23.171	23.171	21.276	21.953
C	24.782	24.782	25.173	25.032
D	13.961	13.961	17.206	18.647
E	8.514	8.514	14.256	16.177
F	13.635	13.635	20.320	23.215
G	-	-	0.340	0.599
SLV	0.036	0.036	-	-
N.S.Coke	0.042	0.042	0.169	0.104
N.G.	13.728	0.887	-	-
Sub-Total	102.259	89.418	102.797	109.535
C. Total	138.242	121.417	133.368	143.988

* The Sub Total includes the non-graded coal.

Source: (i) Coal Controller's Organization, op cit Ref. Table II.1.3; and (ii) Personal Communications, Department of Coal, GOI, New Delhi.

Table II.1.12 : Average Useful Heating Value of Coals Produced# (kcal/kg)

1975/76	5540
1976/77	5545
1977/78	5525
1978/79	5490
1979/80	5340
1980/81	5210
1981/82	5210

By CIL only

Source: Compiled from various sources.

II.1d Coal Washing and Gasification

Owing to the generally poor and deteriorating quality of Indian coals, the beneficiation processes become important.

Washed coals are not only relatively easier to use, they are also easier to transport, and may not pose as many problems for the nation's already overburdened transportation infrastructure. However, washeries for coking coals only have been established so far; although there are plans to establish washeries for certain grades of non-coking coals also.

At present, the CIL operates 13 washeries. Data for the production of washed coal and middlings during 1986/87, are available for these washeries. There are six other washeries also, operated by TISCO, IISCO and SAIL, for which up-to-date information is not readily available.

Coal gasification, by which coal utilization can be made more efficient, has also been tried in India. It involves a reaction between the organic material of coal and the gasifying agent, and ash is obtained as a residue.

An atmospheric fluidized bed gasification plant was set up at Neyveli in 1963. It produced synthesis gas, for the production of ammonia. However, the project had to be abandoned because its operation proved to be uneconomical.

In 1978, the Fertilizer Corporation of India (FCI) set up two fertilizer plants based on the kopper - Totzek entrained - bed coal gasification process. These plants are at Talcher (Orissa) and Ramagundam (Andhra Pradesh). These plants have yet to attain commercial viability. Some of the technical problems assailing the two plants are leakages in waste heat boilers and regenerators, and a failure of certain equipment including raw gas blowers, motor operated valves and so forth. Owing to such maintenance problems, the capacity utilization has remained low. And at least at Ramagundam, the capacity of the three gasifiers (taking into account their heavy maintenance requirements) does not match that of the 300 tonnes/day ammonia unit.

Efforts are now being directed towards pressurized fluidized bed coal gasification for power generation. The discovery of coal deposits in Kalol (Gujarat) has also prompted the ONGC to undertake a feasibility study on in-situ coal gasification.

Table II.1.13 : Washery Statistics

	Coking Coals Supply ('000 tonnes)		Production ('000 tonnes)				
			Washed Coal		Middlings		Rated Capacity (tonnes/hr)
	1981/82	1986/87	1982	1986/87	1982	1986/87	
I. Coal India Ltd	**14473.4**	**14223**	**8907**	**7834**	**4227**	**3945**	**4765**
A. Bharat Coking Coal Ltd.	**7695.3**	**7158**	**4522**	**4106**	**2454**	**2053**	**2670**
1. Barora	-	229	23	56	110	80	N.A.
2. Bhojudih	1771.5	1618	1240	1123	26	21	500
3. Dugda I	1668.5	1134	797	523	519	482	600
4. Dugda II	1740.9	1055	792	504	858	526	500
5. Lodna	259.7	269	233	179	93	51	70
6. Moonidih	-	886	128	620	67	219	N.A.
7. Patherdih	1394.7	1040	900	631	453	408	300
8. Sudamdih	860	927	409	470	328	266	700
B. Central Coalfields Ltd.	**6778.1**	**6730**	**4385**	**3551**	**1773**	**1801**	**2095**
1. Gidi	1742	1551	1000	846	434	533	500
2. Kargali	2264.1	2378	1600	1146	419	526	680
3. Kathara	2089	1929	1223	987	600	499	715
4. Sawang	683	872	562	572	320	243	200
C. Western Coal fields Ltd.	**-**	**335**	**-**	**177**	**-**	**91**	**N.A.**
1. Nandan	-	335	-	177	-	91	N.A.
II. Tata Iron & Steel Co.Ltd.	**2001.1**	**-**	**1833**	**1973.3**	**815**	**-**	**985**
1. Jama Doba	1404.9	N.A.	923	973.3*	181	N.A.	985
2. W Bokaro I	596.2	N.A.	289}		186	N.A.	150
3. W.Bokaro II	-	N.A.	621}	1000.0*	448	N.A.	450
III. Indian Iron & Steel Co Ltd.	**1308.3**	**-**	**764**	**333.3***	**96**	**N.A.**	**550**
1. Chasnala	1308.3	-	764	333.3*	96	N.A.	550
IV. Steel Authority of India Ltd.	**896.2**	**-**	**484**	**506.6***	**254**	**-**	**720**
1. Durgapur (HSL)	848	N.A.	442	N.A.	243	N.A.	360
2. Durgapur (DPL)	48.2	N.A.	42	N.A.	11	N.A.	360
Total	**18679**	**14223**	**11988**	**10647.2**	**5392**	**3945**	**7020**

* These figures are obtained from scaling up of the data available for the period April to December, 1986-87.

Source : (i) Coal Controllers'Organization, op cit Ref. Table II.1.3; and (ii) Personal Communications, Department of Coal, GOI, New Delhi.

Table II.1.14 : Uses of Gasified Coal

Gasification Products	Applications
Low CV* Gas	- Flame stabilisation in utility and industrial boilers - Power generation by combined cycle - Auxiliary fuel
Medium CV Gas	- Production of ammonia and methanol - Industrial and domestic fuel - synthesis gas
High CV Gas	- Industrial and domestic fuel - Chemical feedstock

* CV Calorific Value.

Source : J.D. Pandya, "Environmental Implications of Coal Gasification" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

II.2 HYDROCARBONS

II.2a Hydrocarbon Reserves and Exploration

The total area of sedimentary basins in India is about 1.72 million sq.km, of which, 1.4 million sq.km are on land, and the remaining offshore, within the 200 metres isobath line. Of the 26 sedimentary basins, 13 are of interest geologically. According to one estimate, the prognosticated reserves in these 13 (Category I, II and III) basins are about 17 billion tonnes of oil and oil equivalent of gas.

Compared to the rather large prognostications, the reserves in the proven and (balance) recoverable category are rather small. In fact, as of January 1986, only about 3.2 billion tonnes of in-place oil and gas reserves had been established. And as of January 1986, only 558 million tonnes (MMT) of crude oil and 497 billion cubic metres (bcm) of natural gas reserves were in the proven and recoverable category (*). Only a portion of these reserves may actually be recovered. This clearly highlights the scope for expanding exploratory activity.

The Oil and Natural Gas Commission (ONGC) and Oil India Ltd. (OIL) have expanded their exploratory activity rapidly, particularly since 1981/82. This is evident both from the exploratory meterage drilled, and the number of exploratory wells drilled. In fact, the increase has been more rapid in the offshore areas, and perhaps represents a rationalization of exploratory activity in line with reserve prognostications.

Although a detailed break-up of exploratory drilling basin-wise is not readily available, it is understood that about 95% of the exploratory drilling during the Sixth Five Year Plan (FYP) period (1980/81-1984/85) was in Category I basins. This bias towards exploration in Category I basins is also now begining to be corrected. Experience in the recent past suggests that such a rationalization will be beneficial because additional reserves in Category I basins are likely to be in subtle structural and stratigraphic traps with only small accumulation in most cases, while geophysical surveys indicate that Category II and III basins have several large structures that are favourable for hydrocarbon accumulation.

However, exploratory drilling by both ONGC and OIL has consistently been short of targets. The set targets were not met, partly because of delays in supply of indigenous rigs from BHEL, and delays in finalizing orders for mobile and

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*. The total amounts to about 1005 million tonnes of oil and oil equivalent of gas (1 bcm of gas is approximately equivalent to 0.9 million tonnes of oil).

charter hire rigs. Adverse climatic conditions also affected the performance. Similar delays were also experienced for seismic surveys.

Table II.2.1 : Prognosticated Hydrocarbon Resources*

a.	Total (billion tonnes)	17
b1	In Offshore areas (%)	63
b2	In onshore areas (%)	37
c1	In Category I basins (%)	60
c2	In Category II basins (%)	30
c3	In Cateogory III basins (%)	10

* Excluding Category IV basins. Category IV basins are those, which on the analogy with similar hydrocarbon bearing basins in the world, may be considered prospective (e.g Gondwana Basin, Vindhyan Basin, Deccan Synecline).

a. Figure refers to billion tonnes of oil plus oil equivalent of natural gas.

c1 Proved Petroliferous basins with commercial production (e.g. Bombay High Offshore Basin, Cambay Basin and Upper Assam).

c2 Sedimentary Basins with known occurance of hydrocarbons, but from which, no commercial production has yet been obtained (e.g. Basins in the Assam - Arakan Fold Belt, Bengal, Andaman and Nicobar, Krishna-Godavari, Cauveri, Western Rajasthan and Himalayan Foothills).

c3 Sedimentary Basins in which significant shows of hydrocarbons have not yet been found, but which, on general geological grounds, are considered to be prospective. (e.g. Basins in Kerala-Konkan, Saurashtra and Kutch).

Souree : (i) Government of India, Seventh Five Year Plan, 1985-90, Vol.II, Planning Commission, New Delhi, 1985; and (ii)Department of Petroleum, Indian Petroleum and Natural Gas Statistics, 1985/86, GOI, New Delhi.

Table II.2.2 : Proven and Balance Recoverable Reserves of Crude Oil (million tonnes)

Year	On-Shore		Off-Shore	Total
	Gujarat	Assam	Bombay High	
1970	56.38	71.46	-	127.84
1971	51.08	62.70	-	113.78
1972	52.28	72.90	-	125.18
1973	49.45	77.87	-	127.32
1974	48.45	76.05	-	124.50
1975	45.72	84.41	13.77	143.90
1976	45.79	81.99	147.68	275.46
1977	45.62	82.28	175.28	303.18
1978	47.49	78.50	221.04	347.03
1979	45.34	82.81*	226.29	354.44
1980	52.73	82.65*	230.95	366.33
1981	51.48	89.00*	328.29	468.77
1982	53.18	91.52*	325.18	469.88
1983	90.58	97.03*	338.70	526.31
1984	88.0	99.01*	323.81	510.82
1985	86.61	101.80*	311.10	499.51
1986	98.64	113.83*	345.54	558.01

* Includes crude oil reserves in Nagaland.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.3 : Proven and Balance Recoverable Reserves of Natural Gas (billion cubic metres)

Year	On Shore			Off Shore	Total
	Gujarat	Assam	Rajasthan	Bombay High	
1970	19.66	42.82	-	-	62.48
1971	18.84	43.45	-	-	62.29
1972	16.88	45.25	0.38	-	62.51
1973	16.35	49.71	0.38	-	66.44
1974	16.18	51.30	0.38	-	67.86
1975	15.72	65.24	0.43	6.28	87.67
1976	16.41	61.42	0.43	106.62	184.88
1977	16.20	63.76	0.43	148.08	228.47
1978	15.66	63.62	0.43	186.15	265.86
1979	15.80	63.35*	0.43	264.64	344.22
1980	16.39	63.53*	0.43	270.96	351.91
1981	15.99	65.19*	0.43	329.04	410.65
1982	18.18	70.66*	0.43	330.62	419.83
1983	18.95	78.67*	0.43	377.21	475.26
1984	18.60	81.31*	0.54	377.80	478.25
1985	21.87	87.67*	0.54	368.55	478.63
1986	26.99	91.83*	0.54	377.69	497.05

* Includes Natural Gas Reserves in Tripura and Nagaland.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.4 : Oil and Gas Discoveries in 1986/87

	State/Area	Place/Structure	Nature of find
a.	**Onshore**		
a1	Andhra Pradesh	Talipaka	Gas
		Kaikalur	Oil and Gas
a2	Assam	Namti	Oil
b.	**Offshore**		
b1	West Coast	CD	Oil
		CA	Oil
		B-42	Oil
		B-131	Oil
		R-7A	Oil and Gas

Source : Centre for Monitoring Indian Economy, Current Energy Scene in India, May 1987.

Table II.2.5 : Exploratory Drilling Done by ONGC and OIL

	On-Shore		Off-Shore		Total	
Year	Meterage Drilled ('000)	No. of Wells	Meterage Drilled ('000)	No. of Wells	Meterage Drilled ('000)	No. of Wells
1970/71	106	51+1P	1	-	107	52+1P
1975/76	120	49+1P	19	10	139	59+1P
1976/77	116	49+1P	35	17	151	66+1P
1977/78	113	47+2P	39	20	152	67+2P
1978/79	96	38+1P	43	16	139	54+1P
1979/80	98	43+2P	40	15+1P	138	58+3P
1980/81	96	44+1P	40	15+1P	136	59+2P
1981/82	130	52+2P	39	12	169	64+2P
1982/83	128	57+3P	57	17	185	74+3P
1983/84	157	61+3P	70	22+1P	227	83+4P
1984/85	186	70+5P	62	20+1P	248	90+6P
1985/86*	237	90+4P	100	33+2P	337	123+6P

* Provisional.
P Partly Drilled.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.6 : Targets and Achievements of Exploratory Drilling ('000 metres)

	1980 to 1985			1985/86		
	ONGC	OIL	Total	ONGC	OIL	Total
a. On-Shore						
Target	751.7	158.5	910.2	225.5	43.7	299.2
Achievement	604.1	92.0	696.1	205.3	34.1	239.4
	(80.4)	(58.0)	(76.5)	(91.0)	(78.0)	(80.0)
b. Off-Shore						
Target	275	57.9	332.9	95.5	15.0	110.5
Achievement	243.6	24.2	267.8	91.2	8.6	99.8
	(88.6)	(41.8)	(80.4)	(95.5)	(57.3)	(90.3)

Note : Figures in brackets are % to the targets.

Source : Centre for Monitoring Indian Economy, op cit Ref. Table II.2.4.

Table II.2.7 : Progress of Seismic Surveys (line Kilometres)

State	Upto 1979/80 Total	1980/81 to 1984/85 Total	1985/86 Total	Upto 1985/86 Total	Upto 1985/86 Reflection	Upto 1985/86 Refraction
a. On-Shore	**122840**	**52643**	**34289**	**209772**	**136790**	**72982**
a1 Andhra Pradesh	17210	11548	5493	34251	18787	15464
a2 Assam	17630	8057	8513	34200	23137	11063
a3 Gujarat	44338	14213	9257	67808	46604	21204
a4 Other states	43662	18825	11026	73513	48262	25251
b. Off-shore	**134250**	**120151**	**8316**	**262717**	**258266**	**4451**
c. Total	**257090**	**172794**	**42605**	**472489**	**395056**	**77433**

a1 Includes Tamil Nadu.
a2 Includes Tripura, Mizoram, Arunachal Pradesh and Meghalaya.
a3 Includes Kutch, Maharashtra and Madhya Pradesh for 1979-80.

Source: Department of Petroluem, op cit Ref. Table II.2.1.

II.2b Hydrocarbon Production

Along with exploratory drilling, developmental drilling has also increased substantially in the 1980s; which, in turn, has led to a rapid rise in indigenous crude oil and gas production. From about 8.5 MMT of crude oil and 2.4 bcm of gross natural gas production in 1975/76, the production levels increased to over 30 MMT and 8.1 bcm of oil and gas respectively in 1985/86. This increase is due largely to accelerated production from the Bombay High Offshore Basin. By 1985/86, oil produced from Bombay High accounted for 69% of total crude oil production in the country; while the gross production of its associated and free gas reserves, was about 64%.

Although gross production was 8.1 bcm in 1985/86, net production was less than 5 bcm. Over 38% of gas produced was flared away. As a percentage of gross production, net production has increased during the past decade, but it has not been possible to eliminate flaring. This is due to several reasons. Delays in commissioning down-stream gas utilization facilities is only one factor. There is apparently little flexibility in reducing the production of associated gases, because that is possible only if oil production is also limited -- but such a step may lead to a higher net oil import bill. In fact, it will be possible to limit the production of gas only from fields which have free gas reserves (e.g. South Bassein). The production profile from such fields may be adjusted to the extent gas can be utilized purposefully down-stream.

The petroliferous basins of India are considered to be good prospects for natural gas. Compared to the incremental gas-oil ratios of less than 1200 million cubic metres per million tonnes (mcm/MMT) in all basins until 1985, it is anticipated that the gas-oil ratios of new discoveries during the Seventh FYP period (1985/86-1989/90) will be over 1400 mcm/MMT. To the extent new hydrocarbon discoveries will have associated gas reserves, it will become necessary to develop a suitable gas pipeline system and other down-stream facilities in a coordinated manner.

Besides investing in new fields to commence commercial scale production, oil production from old and depleting fields may also be sustained over a longer time period by applying suitable enhanced oil recovery (EOR) techniques. Until now, water flooding and gas injection have been used most often in India, although these techniques are not always suitable for all types of fields. Pilot tests for chemical flooding, miscible gas injection and thermal methods of EOR are also under way in various fields.

Table II.2.8 : Developmental Drilling Done by ONGC and OIL

Year	On-Shore Meterage Drilled ('000)	On-Shore No. of Wells	Off-Shore Meterage Drilled ('000)	Off-Shore No. of Wells	Total Meterage Drilled ('000)	Total No. of Wells
1970/71	112	50+3P	-	-	112	50+3P
1975/76	145	68+1P	9	5	154	73+1P
1976/77	133	58+1P	14	7	147	65+1P
1977/78	135	59+1P	28	15	163	74+1P
1978/79	126	46	-	-	126	46
1979/80	80	39+2P	29	13	109	52+2P
1980/81	71	38+2P	42	18	113	56+2P
1981/82	145	63+4P	72	34	217	97+4P
1982/83	156	71+4P	105	47	261	118+4P
1983/84	181	79+2P	149	68	330	147+2P
1984/85	180	82+1P	109	51	289	133+1P
1985/86*	283	128+7P	89	44	372	172+7P

* Provisional.
P Partly Drilled.

Source : Department of Petroleum, op cit. Ref. Table II.2.1.

Table II.2.9 : Production of Crude Oil
('000 tonnes)

Year	Onshore			Offshore	Total
	Arunachal	Assam	Gujarat	Bombay High	
1970/71	-	3367	3455	-	6822
1971/72	-	3630	3669	-	7299
1972/73	-	3609	3712	-	7321
1973/74	-	3589	3600	-	7189
1974/75	-	3814	3870	-	7684
1975/76	-	4300	4148	-	8448
1976/77	-	4305	4187	406	8898
1977/78	-	4534	4155	2074	10763
1978/79	-	4085	4238	3310	11633
1979/80	-	3578	3766	4422	11766
1980/81	2	1712	3808	4985	10507
1981/82	2	4795	3422	7975	16194
1982/83	1	5000	3185	12877	21063
1983/84	31	5009	3588	17392	26020
1984/85	51	4893	3910	20136	28990
1985/86*	60	4966	4319	20823	30168

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.10 : Gross Production of Natural Gas (Million Cubic Metres)

Year	On shore		Offshore	Total
	Assam	Gujarat	Bombay High	
1970/71	980	465	-	1445
1971/72	1012	523	-	1535
1972/73	1034	531	-	1565
1973/74	1195	518	-	1713
1974/75	1388	653	-	2041
1975/76	1595	773	-	2368
1976/77	1558	822	48	2428
1977/78	1717	893	229	2839
1978/79	1518	908	386	2812
1979/80	1385	840	542	2767
1980/81	843	842	673	2358
1981/82	1748	758	1345	3851
1982/83	1829	750	2357	4936
1983/84	1954	748	3259	5961
1984/85	2058(a)	775	4408	7241
1985/86*	233(a)	919	5180	8134

* Provisional.

a. Includes one million cubic metres (mcm) of natural gas production from Arunachal Pradesh in 1984-85 and 6 mcm of natural gas in 1985-86.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.11 : Ratio of Proven and Balance Recoverable Reserves to Production

Year	Crude Oil	Natural Gas*
1971	15.83	41.28
1972	16.98	39.97
1973	17.69	39.69
1974	16.62	35.38
1975	17.37	37.95
1976	31.81	75.83
1977	29.77	83.81
1978	30.79	95.98
1979	27.61	111.61
1980	38.97	169.43
1981	31.41	117.80
1982	23.81	90.07
1983	20.93	82.39
1984	18.29	70.12
1985	16.73	60.52

* With respect to gross production of natural gas.

Source:Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.12 : Gross and Net Production of Natural Gas (million cubic metres)

	Gross Prod.	Reinjected	Flared	Net Production
Gujarat (Onshore)				
1970/71	465	-	155	310
1973/74	518	-	144	374
1976/77	822	-	131	691
1979/80	840	-	178	662
1982/83	750	-	55	695
1985/86	919	-	118	801
Assam (Onshore)				
1970/71	980	36	607	337
1973/74	1195	115	692	388
1976/77	1558	190	678	690
1979/80	1385	127	616	642
1982/83	1829	91	876	862
1985/86	2035	66	887	1082
Bombay High (Offshore)				
1970/71	-	-	-	-
1973/74	-	-	-	-
1976/77	48	-	48	-
1979/80	542	-	170	372
1982/83	2357	-	957	1400
1985/86	5180	-	2113	3067
Total				
1970/71	1445	36	762	647
1973/74	1713	115	836	762
1976/77	2428	190	857	1381
1979/80	2767	127	964	1676
1982/83	4935	91	1888	8957
1985/86	8134	66	3118	4950

Source: Department of Petroleum, op cit Ref. Table II.2.1.

II.2c Refining Capability and Consumption of Petroleum Products

Since the early 1970s at least, refining capacity has increased more-or-less to keep pace with the rising demand for petroleum products. However, total refinery output has always remained less than the consumption of refined products. And Indian refineries have processed not only indigenous crudes, but imported crudes as well. Consequently, India has imported not only crudes, but refined products as well.

The sales/consumption of petroleum products increased from 17.9 MMT in 1970/71 to 40.4 MMT in 1985/86. This was due partly to an increase in economic activity. However, persistent shortages in coal supply and electricity -- particularly during the last ten years -- also resulted in an increased demand for petroleum products. Electric power shortages prompted several industrial and commercial establishments to install diesel generators, and agricultural consumers to install diesel pumpsets for stand-by use. Furthermore, certain pricing policies, such as subsidization of kerosene, contributed to a rise in kerosene demand for household cooking by making soft-coke production unprofitable. And as the Government has not allowed the price differential between kerosene and diesel to become too high (apparently to ensure that diesel is not adulterated by kerosene), certain private automobile users have preferred to retrofit their petrol driven cars by even inefficient diesel engines.

Other factors (rising share of traffic through diesel using buses and trucks, dieselization of railways, increasing reliance on tractors for land preparation in agriculture and so forth) have also contributed to a growth of the share of middle distillates in the product demand mix. From about 50% in 1970/71, their share increased to about 55% by 1980/81, and further on to over 58% by 1985/86. However, the share of middle distillates in the refinery product mix remained fairly steady at 50-52% during the 1970s.

It is in this context that the Government sought to rationalize refineries during the Sixth FYP period. With addition to cracking capacity, the share of middle distillates rose to over 54% by 1985/86. Such efforts are planned to continue. Besides, delayed coker and fluidized catalytic cracker (FCC) facilities that already exist, there are plans to install hydrocracker (HC) units also.

Table II.2.13 : Refining Capacity (million tonnes per annum)

Refining Company	Location	Year of Commissioning	Date of Commissioning	Capacity On April 1 1971	Capacity On April 1 1986
BPCL	Bombay	1955	2.2	5.25	6.0
BRPL	Bongaigaon	1979	1.0	-	1.0
CRL	Cochin	1966	2.5	2.5	4.5
HPCL	Bombay	1954	N.A.	3.5	3.5
HPCL	Vizag	1957	N.A.	1.5	4.5
IOC	Barauni	1964	2.0	3.0	3.3
IOC	Digboi	1901	0.5	0.5	0.5
IOC	Gauhati	1962	0.75	0.8	0.85
IOC	Haldia	1974	2.5	-	2.5
IOC	Koyali	1965	2.0	4.3	7.3
IOC	Mathura	1982	6.0	-	6.0
MRL	Madras	1969	2.5	2.5	5.6

Note : During the Seventh FYP period, the capacity of the BRPL refinery at Bongaigaon will be expanded to 3.5 mtpa, that of the IOC refinery at Mathura to 7.5 mtpa (by July 1988), and of the IOC refinery at Koyali to 9.5 mtpa. Moreover, two new grass-root refineries will be set up during the Eighth FYP period : (i) at Karnal, of 6 mtpa throughput capacity; and (ii) at Mangalore, of 3 mtpa capacity. Both the new refineries will have HC units.

Source : Department of Petroleum, op cit Ref. Table III.2.1.

Table II.2.14 : Refining Industry - Crude Throughput and Production of Petroleum Products

	1975/76	1977/78	1979/80	1981/82	1983/84	1985/86
Crude Throughput ('000 t)	22283	24899	27474	30146	35263	42910
Capacity Utilisation (%)	76.0	84.0	81.1	76.9	87.1	87.5
Production ('000t)	20829	23219	25794	28182	32926	39881
Refinery Losses ('000 t)	1454	1679	1680	1964	2337	3029
% Losses	6.5	6.7	6.1	6.5	6.6	7.1

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.15 : Refining Industry -- Capacity Utilization and Losses (1985/86)*

Refinery	Crude Through-put ('000 Tonnes)	Capacity Utilisa-tion (%)	Refinery Product-ion ('000 Tonnes)	Refinery Losses ('000 Tonnes)	% Losses
BPCL, Bombay	6389	99.7	5981	408	6.4
BRPL, Bongaigaon	893	73.9	739	154	17.2
CRL, Cochin	2749	56.9	2560	189	6.9
HPCL, Bombay	4375	117.2	4102	273	6.2
HPCL, Vizag	2659	54.2	2438	221	8.3
IOC, Barauni	2766	76.1	2513	253	9.1
IOC, Digboi	529	102.2	511	18	3.4
IOC, Gauhati	766	81.9	696	70	9.1
IOC, Haldia	2822	103.2	2579	243	8.6
IOC, Koyali	7830	100.0	7305	525	6.7
IOC, Mathura	6075	95.6	5734	341	5.6
MRL, Madras	5057	84.3	4723	334	6.6

* Provisional.

Source: Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.16: Secondary Refining Capacity in 1986
('000 tonnes)

Refinery	CDU	Coking Unit	Vis-breaker	FCC
BPCL, Bombay	6000	-	-	1200(a)
BRPL, Bongaigao	1000	500	-	-
CRL, Cochin	4500	-	1230	1000
HPCL, Bombay	3500	-	-	400
HPCL, Vizag	4500	-	-	1000(a)
IOC, Barauni	3300	1100	-	-
IOC, Digboi	500	40	-	-
IOC, Gauhati	850	300	-	-
IOC, Haldia	2500	-	460	-
IOC, Koyali	7300	-	1000	1000
IOC, Mathura	6000	-	1000	1000
MRL, Madras	5600	-	370(b)	600

CDU : Crude/Atmospheric Distillation Unit.
FCC : Fluid Catalytic Cracker.
a : Two units.
b : Includes Thermal cracker of 0.305mtpa capacity.

Source : Centre for Monitoring Indian Economy, op cit Ref. Table II.2.4.

Table II.2.17 : Refinery Production ('000 tonnes)

	Products	1970/71	1975/76	1977/78	1979/80	1981/82	1983/84	1985/86*
a.	**Light Distillates**	**3021**	**3630**	**4051**	**4459**	**5138**	**6134**	**8253**
a1.	LPG	169	331	383	406	410	514	867
a2.	Mogas	1526	1275	1423	1512	1614	1937	2306
a3.	Naphtha	1205	1910	2120	2415	3004	3578	4955
b.	**Middle Distillates**	**8562**	**10769**	**12079**	**13080**	**14134**	**16873**	**21613**
b1.	Kerosene	2896	2439	2450	2539	2907	3528	4030
b2.	ATF	710	925	1077	1104	1009	1195	1519
b3.	HSD	3840	6285	7129	7975	9042	10862	14624
b4.	LDO	986	946	1224	1230	949	1081	1177
c.	**Heavy Ends**	**5527**	**6430**	**7089**	**8255**	**8910**	**9919**	**10015**
c1.	Fuel Oils	4090	5083	5332	6351	6908	8000	7955
	- Furnace Oil	2987	3595	3454	4086	4015	4588	3791
	- LSHS	1103	1488	1878	2265	2893	3412	4164
c2.	Lube Oils	231	342	413	487	407	470	501
c3.	Petroleum Coke	151	160	155	99	141	136	192
c4.	Bitumen	805	967	992	1103	1298	1069	1107
d.	**Total Production**	**17110**	**20829**	**23219**	**25794**	**28182**	**32926**	**39881**

* Provisional.

Source: Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.18 : Refinery Output Mix (%)

	1970/71	1975/76	1977/78	1979/80	1981/82	1983/84	1985/86
a. Light Distillates	17.6	17.4	17.4	17.3	18.2	18.6	20.7
b. Middle Distillates	50.1	51.7	52.0	50.7	50.2	51.2	54.2
c. Heavy Ends	32.3	30.9	30.6	32.0	31.6	30.1	25.1

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.19 : Sales/Consumption of Petroleum Products ('000 tonnes)

	Products	1970/71	1975/76	1977/78	1979/80	1981/82	1983/84	1985/86
a	**Light Distillates**	**2697**	**3596**	**4228**	**4460**	**5187**	**5600**	**6766**
a1.	L.P.G.	176	336	391	410	492	746	1228
a2.	Mogas	1453	1275	1391	1490	1599	1891	2264
a3.	Naphtha	904	1836	2290	2413	2963	2804	3121
b	**Middle Distillates**	**9040**	**11653**	**13771**	**16321**	**17919**	**20651**	**23725**
b1.	Kerosene	3283	3104	3322	3952	4228	5524	6200
b2.	ATF	689	897	956	1154	1128	1208	1440
b3.	HSD	3837	6595	7106	8638	10345	12600	14738
b4.	LDO	1092	878	1082	1216	1122	1097	1098
c.	**Heavy Ends**	**6175**	**7198**	**7540**	**9102**	**9417**	**9590**	**9895**
c1.	Fuel Oils	4664	5781	5839	7081	7473	7558	7713
	- Furnace Oil	3513	4279	3958	4796	4306	4207	3725
	- LSHS	962	1381	1847	2268	2878	3351	3988
	- HHS	163	121	34	17	-	-	-
c2.	Lubes and Greases	545	441	478	566	592	617	683
	- Lube Oils	523	425	459	546	567	590	651
	- Greases	22	16	19	20	25	27	32
c3.	Bitumen	777	690	908	1069	1292	1050	1118
c4.	Petroleum Coke	07	151	146	185	174	114	149
c5.	Other Misc.	82	135	170	201	175	251	232
d.	**Total**	**17912**	**22447**	**25539**	**29883**	**32523**	**35841**	**40386**

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.20 : Sales/Consumption Mix of Petroleum Products (%)

Product	1970/71	1975/76	1977/78	1979/80	1981/82	1983/84	1985/86*
Light Distillates	15.0	16.0	16.6	14.9	15.9	15.6	16.8
Middle Distillates	50.5	51.9	53.9	54.6	55.1	57.6	58.7
Heavy Ends	34.5	32.1	29.5	30.5	29.0	26.8	24.5

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

II.2d Petroleum Imports and Exports

India is a net oil importer whose oil import bill has increased substantially during the past two decades. From less than 9% of foreign exchange earnings through commodity exports during the 1960s, the net oil import bill increased to over 30% in 1973/74 (following the first oil crisis), and then to over 75% in 1980/81 (after the second oil crisis).

This occurred despite an increase in relative self-sufficiency in oil supplies, from a mere 6% in 1960/61 to over 30% during the 1970s. Although the net oil import bill is reported to have reduced substantially since 1980/81, this is due largely to : (i) a rapid increase in indigenous crude production, as self-sufficiency in oil supplies increased to over 60% by 1983/84; and (ii) weak oil prices in the international market.

Table II.2.21 : Imports/Exports of Crude oil

Year	Quantity ('000 tonnes)			Value (Rs. million)		
	Gross Imports	Exports	Net Imports	Gross Imports	Exports	Net Imports
1970/71	11683	-	11683	1067.2	-	1067.2
1971/72	12951	-	12951	1470.2	-	1470.2
1972/73	12084	-	12084	1463.7	-	1463.7
1973/74	13873	18	13855	4163.9	4.2	4159.7
1974/75	14016	-	14016	9169.9	-	9169.9
1975/76	13624	-	13624	10517.6	-	10517.6
1976/77	14048	-	14048	11759.1	-	11759.1
1977/78	14507	-	14507	12462.0	-	12462.0
1978/79	14657	-	14657	12511.7	-	12511.7
1979/80	16121	-	16121	21875.3	-	21875.3
1980/81	16248	-	16248	33489.7	-	33489.7
1981/82	15298	838	14460	37363.8	1962.3	35401.5
1982/83	16949	4552	12397	40437.4	10633.7	29803.7
1983/84	15967	5522	10445	35410.5	12311.0	23099.5
1984/85	13642	6478	7164	34303.4	15631.6	18671.8
1985/86*	15144	528	14616	36868.0	1351.5	35516.5

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1

Table II.2.22 : Imports and Exports of Petroleum Products

Year	Quantity ('000 tonnes) Gross Imports	Exports	Net Imports	Value (Rs. million) Gross Imports	Exports	Net Imports
1970/71	1084	332	752	299.1	46.7	252.4
1971/72	2147	136	2011	468.8	39.1	429.7
1972/73	3525	126	3399	605.8	81.6	524.2
1973/74	3548	161	3387	1245.0	80.5	1164.5
1974/75	2648	175	2473	1950.0	174.6	1775.4
1975/76	2218	170	2048	2043.4	139.6	1903.8
1976/77	2624	74	2550	2482.3	68.9	2413.4
1977/78	2879	47	2832	3053.4	56.9	2996.5
1978/79	3878	44	3834	4299.9	41.1	4258.8
1979/80	4724	88	4636	10823.9	240.2	10583.7
1980/81	7289	36	7253	19175.2	84.1	19091.1
1981/82	4884	55	4829	14531.6	151.3	14380.3
1982/83	5028	795	4233	15539.4	1337.9	14201.5
1983/84	4328	1472	2856	12707.5	3569.6	9137.9
1984/85	6092	933	5159	19149.1	2550.3	16598.8
1985/86*	3865	1963	1902	12736.0	5095.7	7640.3

* Provisional

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.23 : Net Oil Imports as a percentage of Imports and Exports

Year	As a % of Imports	As a % of Exports
1970/71	6.5	6.9
1971/72	8.1	9.1
1972/73	7.8	7.4
1973/74	14.1	16.1
1974/75	20.3	27.5
1975/76	19.9	26.0
1976/77	23.1	22.8
1977/78	20.7	23.0
1978/79	18.3	21.8
1979/80	23.9	34.1
1980/81	26.6	49.9
1981/82	26.0	45.3
1982/83	20.8	33.8
1983/84	14.6	23.4
1984/85	11.3	16.5
1985/86*	19.3	34.1

* Provisional.

Source: Department of Petroluem, op cit Ref. Table II.2.1.

II.2e Storage of Crude Oil and Refined Products

Stock building and drawdown have influenced the evolution of the international oil market considerably in the past. In India strategic storage of oil and its products is seen to provide some immunity from a sudden scarcity of oil in the international market and from large fluctuations in its price.

Strategic storage of oil to meet its demand for about 3 months is seen to provide an adequate balance between high costs of storage and risks of no storage at all. In keeping with the rising petroleum demand in India, the stocks of crude oil have been built up gradually during the past five-six years. Same is the case with refined products, except during 1983/84 and 1984/85.

It may be mentioned that the need for storage is influenced most by the level of indigenous demand for products, rather than by refining capacity. Therefore, the actual refinery expansion programme is not likely to influence the storage capacity expansion programme substantially.

Table II.2.24 : Crude Oil Stock Changes ('000 tonnes)

Year	Addition (+)/ Depletion (-)
1970/71	126
1971/72	208
1972/73	77
1973/74	86
1974/75	(-)204
1975/76	(-)211
1976/77	(-)49
1977/78	372
1978/79	316
1979/80	413
1980/81	919
1981/82	508
1982/83	304
1983/84	1202
1984/85	598
1985/86*	1874

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.25 : Changes in Stocks of Petroleum Products* ('000 tonnes)

	1976/ 77	1977/ 78	1978/ 79	1979/ 80	1980/ 81	1981/ 82	1982/ 83	1983/ 84	1984/ 85	1985/ 86*
a. Light Distillates	**4**	**113**	**(-)5**	**102**	**(-)2**	**56**	**(-)25**	**(-)208**	**(-)159**	**(-)287**
a1 Naphtha	(-)19	90	12	68	(-)15	100	33	2	71	38
a2 Others	23	23	(-)17	34	13	(-)44	(-)58	(-)210	(-)230	(-)325
b. Middle Distill-ates	**(-)82**	**364**	**(-)103**	**434**	**443**	**215**	**669**	**159**	**(-)23**	**1366**
b1 HSD/LDO	(-)62	228	(-)133	225	299	44	381	37	(-)53	789
b2 Others	(-)20	136	30	209	144	171	288	122	30	577
c. Heavy Ends	**(-)41**	**34**	**(-)115**	**11**	**39**	**217**	**5**	**(-)10**	**(-)219**	**318**
d. Total	**(-)119**	**511**	**(-)223**	**547**	**480**	**488**	**649**	**(-)59**	**(-)401**	**1397**

* Addition to Stocks (+)/Depletion (-).

Source : Department of Petroleum, op cit Ref. Table II.2.1.

II.2f Natural Gas and LPG

Natural gas was either flared or reinjected (for secondary recovery) during the 1980s and 1960s. It began to be used as an energy source outside the producing company (for example for power generation), or as a feedstock for the fertilizer and petrochemical industries only during the 1960s. A steady growth of down-stream utilization of natural gas is evident, although large quantities still continue to be flared.

As LPG is a clean fuel that can be used for domestic cooking, the Government has plans to increase its supplies considerably. During the 1970s, LPG was obtained entirely from refinery flue gases. With the commissioning of LPG extraction plants in Bombay (Maharashtra) and Duliajan(Assam) in 1981 and 1982 respectively, LPG is now extracted from natural gas (while the lean gas is fed to fertilizer plants or utilized elsewhere).

At present, LPG is distributed through retailers and agents by the marketing divisions of the Indian Oil Corporation (IOC), Bharat Petroleum Corporation Ltd. (BPC), Hindustan Petroleum Corporation Ltd. (HPCL) and the Indo-Burma Petroleum (IBP) Company Ltd. The supplies are concentrated primarily in four metropolitan areas -- Bombay, Calcutta, Delhi and Madras -- and to some other smaller cities and towns. It is expected that with the increased supplies over the next two to three years, the distribution network will cover smaller towns and cities as well. There are plans to commission nearly 1.7 million new LPG connections each year to 1989/90.

Table II.2.26 : Industry-wise Offtakes of Natural Gas (million cubic metres)

	Energy Purposes						Non Energy Purposes			
Year	Power Generation	Industrial Fuel	Tea Plantation	LPG Shrinkage	Domestic Fuel	Captive Use	Fertilizer Industry	Petrochemicals	Others	Total
1970/71	261	116	15	-	-	68	187	-	-	647
1971/72	313	129	19	-	-	61	196	-	-	718
1972/73	339	148	20	-	Neg	63	201	-	-	771
1973/74	323	157	22	-	Neg	81	179	-	-	762
1974/75	354	164	29	-	6	80	318	-	-	951
1975/76	366	143	33	-	13	104	463	-	2	1124
1976/77	344	155	38	-	15	142	663	-	24	1381
1977/78	372	165	39	-	13	171	673	9	22	1464
1978/79	560	175	43	-	13	176	721	5	18	1711
1979/80	514	156	39	-	13	174	755	7	18	1676
1980/81	492	163	45	-	14	176	611	5	16	1522
1981/82	612	166	47	37	15	327	991	8	19	2222
1982/83	1025	185	51	100	14	399	1155	7	21	2957
1983/84	1209	230	56	161	16	411	1283	10	23	3399
1984/85	1454	250	62	190	18	531	1603	11	22	4141
1985/86*	1299	223	78	275	21	520	2500	10	24	4950

* Provisional.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

Table II.2.27 : Prouction and Distribution of LPG

	1981/82	1982/83	1983/84	1984/85	1985/86
Production ('000 tonnes)					
- Total	483	575	737	873	1230
- from refineries	410	406	514	596	867(a)
- from natural gas	73	169	23	277	363(a)
No. of distributors	1169(b)	1565(b)	1791(b)	2223(c)	2742(c)

a. Provisional.
b. as on Jan.1.
c. as on Apr.1.

Source : Department of Petroleum, op cit Ref. Table II.2.1.

II.3a Installed Capacity in Utilities

Power generating capacity which is owned and operated by utilities, has grown at the rate of over 9% per annum since 1950. Of the nearly 48,600 MW commissioned until March 31, 1987, nearly 50% had been added during the past nine years alone. During the Sixth FYP period, approximately 3000 MW were commissioned every year.

The hydro-thermal mix has changed substantially since the early 1970s. In 1970/71, the installed hydro capacity was over 80% of the total thermal capacity installed (i.e. including coal based steam thermal power stations, gas turbines and diesel generators). By 1980/81, hydro capacity had fallen to 67% of thermal capacity; and by 1986/87, it reduced further to nearly 50%. It is not easy to judge an optimal or desirable hydro-thermal mix, as it may depend upon the system load curve, performance of various types of plants and so on. However, it is believed that efforts must be made to increase the share of hydro capacity in future years.

Perhaps one of the most important reasons for the decline in the share of hydro capacity is that its gestation period is considerably longer than that of thermal capacity. Although there have been time over-runs in commissioning both hydro and thermal projects in the past, such delays have been usually less for the latter projects. This is because equipment and construction procedures for thermal projects are largely independent of site conditions, and can therefore be standardized. Such standardization however, may not be possible for hydro power plants.

India has also expanded its nuclear, and small hydro capacity over the past two decades. These aspects are discussed further in sections II.3c and in chapter V respectively.

Table II.3.1: Installed Capacity in Utilities
(MW)

	Hydel	Thermal*	Nuclear	Total
1950	559	1153	-	1712
1955	939	1756	-	2695
1960/61	1917	2736	-	4653
1965/66	4124	4903	-	9027
1970/71	6383	7906	320	14609
1975/76	8464	11013	540	20017
1980/81	11791	17563	760	30114
1981/82	12173	19312	760	32245
1982/83	13056	21447	760	35263
1983/84	13856	24388	995	39239
1984/85	14470	27026	995	42491
1985/86	15477	29856	1230	46563
1986/87	15963	31394	1230	48587

* Includes coal based steam thermal plants, gas turbines and diesel generating stations.

Source : Centre for Monitoring Indian Economy [CMIE], Basic Statistics Relating to the Indian Economy, Vol I : All India, August 1987.

Table II.3.2 : Installed Capacity in Utilities By Region --As on March 31 of Each Year (MW)

	1971	1974	1977	1980	1984	1987*
A Northern Region	**3152.55**	**4179.04**	**5634.28**	**8224.02**	**11179.78**	**13365.02**
- Hydro	1934.74	2200.47	2698.77	3946.38	4771.02	5203.02
- Steam Thermal	1098.03	1599.70	2586.60	3976.90	5908.30	7494.60
- Diesel	107.28	136.37	106.41	68.24	60.46	47.40
- Gas	12.50	22.50	22.50	12.50	-	180.00
- Nuclear	--	220.00	220.00	220.00	440.00	440.00
B Western Region	**4023.83**	**4070.11**	**5607.05**	**7808.52**	**11975.00**	**14683.00**
- Hydro	1131.32	1037.32	1668.30	1790.30	1810.30	2092.30
- Steam Thermal	2377.60	2536.00	3460.00	5541.00	9448.00	11442.00
- Diesel	40.91	22.79	4.75	3.22	2.70	2.70
- Gas	54.00	54.00	54.00	54.00	294.00	726.00
- Nuclear	420.00	420.00	420.00	420.00	420.00	420.00
C Southern Region	**4034.71**	**4516.34**	**5634.22**	**7207.31**	**9397.81**	**12589.73**
- Hydro	2840.35	3080.03	3759.13	4593.23	5933.23	7492.23
- Steam Thermal	1171.50	1412.50	1852.50	2592.50	3157.50	4607.50
- Diesel	2.86	3.81	2.59	1.58	2.08	--
- Gas	20.00	20.00	20.00	20.00	20.00	20.00
- Nuclear	--	--	--	--	235.00	470.00
D Eastern Region	**3305.47**	**3686.08**	**4327.52**	**4866.74**	**6076.88**	**7765.25**
- Hydro	409.51	579.93	819.93	906.88	980.23	1080.23
- Steam Thermal	2861.05	3068.56	3469.05	818.23	4949.03	6545.00
- Diesel	34.91	37.59	38.54	41.63	47.62	40.02
- Gas	--	--	--	100.00	100.00	100.00
- Nuclear	--	--	--	--	--	--
E North Eastern Region	**192.39**	**211.99**	**265.52**	**341.24**	**709.39**	**873.19**
- Hydro	67.31	67.55	78.77	147.18	310.78	313.28
- Steam Thermal	--	35.00	65.00	62.50	185.00	327.00
- Diesel	43.58	40.44	40.25	50.06	66.11	60.41
- Gas	81.50	69.00	81.50	81.50	147.50	172.50
- Nuclear	--	--	--	--	--	--
F All India	**14708.95**	**16663.56**	**21468.59**	**28447.83**	**39338.86**	**49275.46**

* Provisional.

A Includes Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Uttar Pradesh, Chandigarh and Delhi.

B Includes Gujarat, Madhya Pradesh, Maharashtra, Goa, Daman-Diu, Dadra and Nagar Haveli.

C Includes Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondicherry and Lakshadweep.

D Includes Bihar, Orissa, West Bengal, DVC, Andaman and Nicobar Islands and Sikkim.

E Includes Assam, Manipur, Meghalaya, Tripura, Arunachal Pradesh, Mizoram and Nagaland.

Source : CEA, Public Electricity Supply, All India Statistics ----- General Review, Various issues.

Table II.3.3: Gestation Period of Power Projects

For Units Commissioned in Year	Average Gestation Period (months)				Number of Units			
	Hydel	Thermal	Gas	Nuclear	Hydel	Thermal	Gas	Nuclear
1980/81	79	83	-	155	7	8	-	1
1981/82	114	80	56	-	4	9	4	-
1982/83	113	84	59	-	9	12	2	-
1983/84	145	74	81	187	17	16	1	1
Average	121	79	60	171	37	45	7	2

Source: Planning Commission, Paper on "Gestation Period for Commissioning of Hydel, Thermal and Nuclear Power Projects".

Table II.3.4 : Micro/Mini/Small Hydro Stations in 1986/87

Region	Existing Stations		Under Construction	
	Number	Installed Capacity(MW)	Number	Installed Capacity(MW)
Northern	44	76.21	31	69.13
Western	2	13.80	7	17.78
Southern	2	10.22	16	48.54
Eastern	11	27.20	6	29.60
North Eastern	34	47.65	26	35.56
Total	93	175.08	86	200.61

Source : CMIE, Current Energy Scene in India, May 1987.

II.3b Utility Generation

Like for utility capacity, utility generation has also grown rapidly over the past four decades. The growth of gross generation averaged over 10% per annum between 1950 and 1986/87; and nearly doubled during the nine year period 1977/78 to 1986/87.

The hydro-thermal generation mix also changed substantially, particularly since 1970/71. While the ratio of hydro to thermal generation varied between 1:1 and 1:1.25 during the 1950s and 1960s, it began to decline steadily during the 1970s. In 1986/87, it was 1:2.4. One of the reasons for this relative increase in thermal generation is the comparatively smaller gestation periods for thermal projects smaller -- which has led to a rise in the share of thermal capacity.

Another reason for a decline in the share of hydro generation is a gradual reduction in the average utilization rate of hydro projects. This perhaps suggests that hydro plants are being used (on an average at the All India level) increasingly for peaking purposes. However, there may be significant differences between regions. For instance, in the Northern Region, the average gross generation from hydro projects increased from about 3400 KWh/kW in 1970/71 to about 3900 kWh/kW in 1985/86.

The average utilization rates of thermal power stations however, show no significant trends. While the average plant load factor of coal based thermal projects has remained below 52%, there are significant differences at the regional and state level. The reasons for and the implications of, such low plant load factors are discussed further in section II.3d.

The contribution of nuclear projects is discussed further in section II.3c.

Table II.3.5: Annual Gross Generation in Utilities (GWh)

	Hydel	Thermal*	Nuclear	Total
1950	2520	2587	-	5107
1955	3742	4850	-	8592
1960/61	7837	9100	-	16937
1965/66	15225	17765	-	32990
1970/71	25248	28162	2417	55827
1975/76	33302	43303	2626	79231
1980/81	46542	61301	3001	110844
1981/82	49565	69515	3021	122101
1982/83	48373	79868	2022	130263
1983/84	49954	86677	3546	140177
1984/85	53785	98770	4078	156633
1985/86	50933	114119	4985	170037
1986/87	53764	128818	5023	187605

* Includes gross generation from steam thermal plants, gas turbines and diesel generators.

Source : CMIE, op cit Ref. Table II.3.1.

Table II.3.6: Annual Gross Generation in Utilities by Region (GWh)

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
A Northern Region	**11863**	**16317**	**23858**	**29227**	**37077**	**46134**
Hydro	6616	9420	11464	15477	18536	19679
Steam Thermal	5211	6333	11288	12610	17988	25164
Diesel	36	69	10	5	2	-
Gas	neg	8	2	4	-	-
Nuclear	-	488	1095	1131	552	1291
B Western Region	**16912**	**19825**	**25981**	**32077**	**40188**	**57376**
Hydro	5478	5386	7651	7945	6550	5942
Steam Thermal	8945	12463	16069	22310	31022	48344
Diesel	15	4	neg	neg	neg	-
Gas	57	64	103	76	1145	1130
Nuclear	2417	1901	2157	1746	1470	1960
C Southern Region	**15710**	**17574**	**21714**	**27032**	**33682**	**43496**
Hydro	11679	11930	13077	19354	20247	21361
Steam Thermal	4030	5640	8635	7677	13433	20403
Diesel	neg	neg	1	1	2	-
Gas	1	4	1	-	-	-
Nuclear	-	-	-	-	-	1732
D Eastern Region	**10959**	**12428**	**15977**	**15393**	**17922**	**21167**
Hydro	1316	2036	2456	2334	2562	2960
Steam Thermal	9611	10372	13509	12928	15128	18158
Diesel	32	20	11	28	19	-
Gas	-	-	-	102	212	49
Nuclear	-	-	-	-	-	-
E North Eastern Region	**385**	**544**	**803**	**898**	**1395**	**1837**
Hydro	160	200	188	367	478	998
Steam Thermal	-	45	242	194	344	708
Diesel	31	32	33	19	21	-
Gas	194	267	341	318	552	131
Nuclear	-	-	-	-	-	-

neg < 0.5 GWH.

Source : CEA, op cit Ref. Table II.3.2.

Table II.3.7: Annual Utilization
(%)

	Hydel	Thermal	Nuclear	Total
1970/71	45.15	40.66	65.69	43.32
1975/76	44.91	44.88	46.83	44.96
1980/81	45.05	39.84	39.83	41.87
1981/82	46.48	41.09	40.10	43.09
1982/83	42.29	42.51	26.83	42.05
1983/84	41.15	40.57	36.96	40.67
1984/85	42.43	41.71	42.51	41.98
1985/86	37.56	43.63	42.78	41.59
1986/87	38.44	46.84	46.61	44.07

Source : CMIE, op cit Ref. Table II.3.1.

Table II.3.8: Utilization of Thermal Power Stations in 1985/86 (%)

Northern Region	
Badarpur (Delhi)	46.0
Delhi	63.8
Haryana	32.8
Punjab	58.9
Rajasthan	57.5
Singrauli	68.8
Uttar Pradesh	37.3
Western Region	
Gujarat	53.2
Korba	74.4
Madhya Pradesh	53.3
Maharashtra	54.8
Southern Region	
Andhra Pradesh	64.8
Karnataka	33.5
Neyveli	74.9
Ramagundam	72.1
Tamil Nadu	56.5
Eastern Region	
Bihar	34.1
Bokaro (DVC)	51.8
Chandrapura (DVC)	47.1
Durgapur (DVC)	52.6
Orissa	31.7
West Bengal	42.2
North Eastern Region	
Assam	27.5
All India	52.4

Source : CMIE, op cit Ref. Table II.3.4.

II.3c Nuclear Power

As on March 31, 1987, the installed nuclear capacity was 2.5% of total installed utility capacity, and its gross generation was nearly 2.7% of total utility generation. Three nuclear power stations are in commercial operation at Tarapur (Maharashtra), Rowatbhata (Rajasthan) and Kalpakkam (Tamil Nadu). All are based on the heavy-water reactor technology. The functioning of the three nuclear power stations has been beset with problems in recent years. Large shut-down times have been reported, particularly in the nuclear station at Rajasthan.

A fourth nuclear power station is under construction at Narora (Uttar Pradesh). It will have two pressurized heavy water reactor units of 235 MWe each, using natural uranium as fuel. Although the plant at Narora was initially planned to be commissioned during 1981/82, it is now expected to be completed only by 1988/89. The major reasons for slippages in the construction schedule have been problems in acquiring land, delays in finalizing designs to suit seismic requirements, delays in fabricating certain critical equipment, and non-availability of certain construction materials.

With indigenously available natural uranium reserves, India can support a nuclear power programme of about 8000 MW (Report of the Working Group on Energy Policy, Government of India, 1979). Therefore, there is considerable scope for expanding the country's nuclear programme from present day levels. Efforts are being made in this direction. The potential of course, can multiply several-folds if the fast-breeder reactor technology is introduced.

In addition, India also has large thorium oxide reserves (about 363,000 tonnes), which can also support a large nuclear programme. However, the technology for using thorium for power generation, may have to be developed in India only.

Table II.3.9: Capacity and Generation from Nuclear Power Stations

	TAPS	RAPS	MAPS
A Capacity (MW)	2 x 160	2 x 220	2 x 235
B Date of Commercial Operation			
- Unit I	Nov 1,1969	Dec 16,1973	Jan 27,1984
- Unit II	----	Apr 1,1981	Mar 21,1986
C Generation (GWh)			
1980/81	1649	906	--
1981/82	1821	889	--
1982/83	1358	440	--
1983/84	1701	1075	--
1984/85	1757	940	173
1985/86	1781	1189	1133

Source : CMIE, op cit Ref. Table II.3.4.

Table II.3.10: Stoppages of Atomic Power Plants (Hours)

Section/Unit	1983	1984	1985	1986
A. TAPS				
- Unit I	3365	1095	2566	806
- Unit II	1241	3168	701	3145
B. RAPS				
- Unit I(a)	Shut down	Shut down	6845	Shut down
- Unit II	2081	2915	2540	2017
C. MAPS				
- Unit I (b)	-	2021	3933	4125
- Unit II (c)	-	-	-	2935

a. RAPS Unit I has not been functional due to the end shield problem, except for a period of about 3 months in 1985.

b. MAPS Unit I lost about 4 months in 1986 due to the failure of the main transformer.

c. A major portion of the time lost by MAPS II was due to a problem in the fuel transfer system outside the reactor.

Source : CMIE, op cit Ref. Table II.3.4.

II.3d Peak and Energy Deficits

The power supply situation in India is characterized by peak and energy shortages. Electricity peaking and energy deficits are expected to continue over the next few years. A peaking deficit of over 10,000 MW and an energy shortage of over 27,700 GWh are projected for 1989/90 (see CEA, Twelfth Electric Power Survey of India, New Delhi, August 1985).

Perhaps the key reason for such shortages is the insufficiency of financial resources. However, it may be noted that since the mid-1960s, the outlay for the power sector has been rather high, at 15 to 20% of the total public sector outlay, and the scope for increasing its share is therefore limited. Consequently, the power industry has little choice but to enhance its internal resource generation.

One of the ways may be restructuring its tariffs in line with costs of power generation and supply. Another way may be to reduce slippages and delays in commissioning generation projects -- which in turn lead to cost over-runs as well. However, it has been observed that slippages in construction schedules are themselves a consequence of non-availability of sufficient financial resources.

Moreover, availability and plant load factors of thermal power projects, which are relatively low in India, also have a substantial scope for improvement. The availability of thermal power generating units in the developed countries is significantly higher than what may be considered as normative (for power sector planning) in India. This may be due to several factors: poor quality of coal used in boilers in India, lack of coal processing facilities, unavailability of a properly trained work force, inadequate or insufficient control equipment, and so forth. The fact that the peak availability norms adopted for planning purposes during the Seventh FYP period are lower than those of the Sixth FYP period, is only a reflection of the recognition of the difficulties experienced. It may be noted that these norms (for planning purposes) are quite different from the actual experience in the recent past from 1977/78 to 1982/83: planned maintenance 12.4%, forced outage rate 18.5%, partial outage rate 20% and auxiliary consumption 12%. It is therefore clear that the availability norms adopted even for the Seventh FYP period are based on an a priori assumption that the performance of thermal power stations will improve.

However, the peaking capability of stabilized thermal units is higher than that of newly established units. It is estimated that a thermal unit attains a stable peaking capability only after about a year of operation. Despite this, normative energy generation capability is expected to be achieved only after three years of operation. As thermal

capacity has increased rather rapidly in recent years (section II.3a), a rather low average plant load factor that has been observed, may be due to this reason.

While peaking capability norms for thermal units are low, those for hydro units are substantially higher -- this reflects past experience. The planned unavailability of hydro units during peak time is taken as nil, only because their maintenance work can be scheduled during off-peak periods and in months/seasons when the system demand is low.

Table II.3.11 : Power Rwquirement, Supply and Deficit/Surplus (GWh)

Region	1984/85	1985/86	1986/87
Northern Region			
Requirement	44722	48504	55006
Availability	38471	43303	49807
Surplus(+)/Deficit(-)	(-)6251	(-)5201	(-)5199
Surplus(+)/Deficit(-)%	(-)14	(-)10.7	(-)9.5
Western Region			
Requirement	46430	51311	57694
Availability	46118	50595	55263
Surplus(+)/Deficit(-)	(-)312	(-)716	(-)2431
Surplus(+)/Deficit(-)%	(-)0.7	(-)1.4	(-)4.2
Southern Region			
Requirement	39729	45535	51178
Availability	39810	41298	45536
Surplus(+)/Deficit(-)	(+)81	(-)4237	(-)5642
Surplus(+)/Deficit(-)%	(+)0.2	(-)9.3	(-)11.0
Eastern Region			
Requirement	22957	23643	26549
Availability	18982	20376	21860
Surplus(+)/Deficit(-)	(-)3975	(-)3276	(-)4689
Surplus(+)/Deficit(-)%	(-)17.3	(-)13.8	(-)17.7
North Eastern Region			
Requirement	1594	1753	1929
Availability	1632	1690	1810
Surplus(+)/Deficit(-)	(+)38	(-)63	(-)119
Surplus(+)/Deficit(-)%	(+)2.4	(-)3.6	(-)6.2
All India			
Requirement	155432	170746	192356
Availability	145013	157262	174276
Surplus(+)/Deficit(-)	(-)10419	(-)13484	(-)18080
Surplus(+)/Deficit(-)%	(-)6.7	(-)7.9	(-)9.4

Source: CMIE, op cit Ref. Table II.3.4.

Table II.3.12: Plan-Wise Slippages in Additional Installed Capacity

Plan	Target (MW)	Achievement (MW)	Slippage (%)
First Plan			
1951 to 1956	1300	1100	15.4
Second Plan			
1956 to 1961	3500	2250	35.7
Third Plan			
1961 to 1966	7040	4520	35.8
Annual Plan			
1966 to 1969	5430	4120	24.1
Fourth Plan			
1969 to 1974	9264	4579	50.5
Fifth Plan			
1974 to 1979	12499	10202	18.4
Annual Plan			
1979/80	2945	1799	38.9
Sixth Plan			
1980 to 1985	19666	14226	27.7
1980/81	2687	1823	32.2
1981/82	4087	2175	46.8
1982/83	4354	3060	29.7
1983/84	4236	4088	3.5
1984/85	4302	3080	28.4
Seventh Plan			
1985 to 1990	22245	-	-
1985/86	4460	4223	5.3
1986/87	3396	2627	22.6
1987/88	4887	-	-

Source : CMIE, op cit Ref. Table II.3.4.

Table II.3.13: Finances of the Power Sector
(Rs. million)

Plan	Outlay for Power	Total Outlay	Share of Power in total plan outlay (%)
Third Plan 1961 to 1966	12523	85765	14.6
Annual Plan 1966 to 1969	12125	66241	18.3
Fourth Plan 1969 to 1974	29317	157788	18.6
Fifth Plan 1974 to 1979	73995	394262	18.8
Annual Plan 1979/80	22405	121765	18.4
Sixth Plan			
1980 to 1985	182986	1092917	16.7
1980/81	26568	148324	17.9
1981/82	31823	182109	17.5
1982/83	37085	212829	17.4
1983/84	40925	250875	16.3
1984/85	46585	298780	15.6
Seventh Plan			
1985 to 1990(a)	342735	1800000	19.1
1985/86 (b)	57188	342182	16.7
1986/87 (c)	74057	390515	19.0

a. Planned Outlay.
b. Revised Estimates.
c. Approved Outlay.

Source : CMIE , op cit Ref. Table II.3.4.

Table II.3.14: International Standards for Capacity Planning for Thermal Power stations

Equipment	Availability (%)	Forced Outage Rate (%)	Planned Maintenance Rate (%)
Boiler	85	7	8
Turbine	95	2	3
Generator	98	2	nil
Other Equipment	98	2	nil
Overall	76	13	11

Source : CEA, Report of the subgroup on Norms for Capacity Planning for the Seventh Plan, January 1984.

Table II.3.15: Peaking Capability of Stabilized Thermal Units

Item	Norms Adopted for VIth FYP period (%)	Norms Adopted for VIIth FYP period (%)
Planned Maintenance	3.5	5
Forced Outrage Rate*	18.5	17
Partial Outrage Rate	10.0	15
Auxiliary Consumption	9.0	10
Spinning Reserve	nil	5
Overall Peak ability	64.4	57.3

* Higher by 5% in the Eastern and North-Eastern regions.

Source : CEA, op cit Ref. Table II.3.14.

Table II.3.16: Norms for Energy Generation From New Thermal Units*

	kWh/kW per year
1st Year	2500
2nd Year	4000
3rd Year	5000
4th Year	5350

* Unit capacity of 210 MW and 500 MW.

Source : CEA, op cit Ref. Table II.3.14.

Table II.3.17: Peaking Capability of Hydro Plants

Item	Norm (%)
Planned Maintenance	nil
Capital Maintenance	3.0
Forced Outage Rate	9.5
Overall Peak Availability	87.8

Source : CEA, op cit Ref. Table II.3.14.

II.3e Non-Utility Generation

Owing to peak and energy deficits in the utility power supply, and the stated Government policy of preferential power supply to rural areas, several industrial and commercial establishments in urban areas have installed captive generation facilities. The term "captive" here refers to the fact that the power generating equipment so installed is used to meet only one's own electricity requirements. Captive generation in the residential sector is also not unknown.

Captive or non-utility generation may be divided broadly into three distinct economic categories: (i) Cogeneration, where process heat and electric power are produced simultaneously; (ii) Stand-by captive generation, which is used as a back-up in the event of a failure of utility power supply; and (iii) Pure captive generation, which is used to augment utility supply to meet power requirements. While cogeneration increases the overall efficiency of an industrial process and is desirable from the viewpoint of energy conservation, stand-by and pure captive generation is fossil-fuel based. It is not planned by the organized power supply sector, and is a result of decisions taken by individual electricity consumers -- in effect, it is a short term response to the power shortage situation.

The CEA compiles some information relating to non-utility generation systematically, but only from industrial units which have captive capacities of over 100 kW or a contract demand of at least 500 kVA. The most recent period for which such information is available, is 1983/84.

Non-utility generating capacity (as per data available from the CEA) has remained at about 10-11% of the total installed utility capacity in India since 1970/71. However, its average utilization rate has declined from 3450 kWh/kW in 1970/71 to just over 2500 kWh/kW in 1983/84.

Although further details by type of industry and type of captive plant are available, the data obtained from the CEA have two major gaps: (i) there is no information on the use of small (mostly diesel based) captive generators in industrial establishments which have less than 100 kW of captive capacity; and (ii) there is no information on the monthly or seasonal variations in the use of captive generation facilities.

Table II.3.18: Captive Generation and Capacity (All India)

	Installed Capacity (MW)	Energy Generated(GWh)	Utilization Factor (%)
1970/71			
Total	1516.868	5347.239	40.24
1973/74			
Total	1732.700	6067.470	39.97
1976/77			
Steam	1783.658	6897.703	44.14
Diesel	423.467	294.792	7.94
Others	17.930	47.840	30.45
Total	2225.055	7240.335	37.14
1979/80			
Steam	2021.612	7225.600	40.97
Diesel	720.580	825.710	13.08
Others	56.882	105.730	21.21
Total	2799.074	8157.040	33.26
1982/83			
Steam	2442.384	8497.050	39.71
Diesel	1306.842	1406.270	12.28
Others	56.870	85.680	17.19
Total	3806.096	9989.000	29.96
1984/85			
Steam	2803.181	9966.550	40.58
Diesel	2077.059	2001.180	10.99
Others	158.219	335.320	24.19
Total	5038.059	12303.050	27.87

Source : CEA op cit Ref. Table II.3.2.

Table II.3.19: Captive Generation By Industries

	Industry	No. of factories	Installed Capacity (MW)	Energy Generated (GWh)	Utilization Factor (%)
	1970/71				
a.	Aluminium	7	147.8	1041.236	80.42
b.	Chemicals	79	97.582	414.431	48.48
c.	Fertilizers	14	87.407	444.870	58.10
d.	Iron & Steel	7	368.272	1252.635	38.83
e.	Mineral Oil and Petroleum	9	81.601	316.429	44.26
f.	Paper	28	69.605	383.860	48.90
g.	Sugar	140	208.511	390.890	21.4
	Total(a to g)	284	1080.778	4244.351	44.83
	Total (All Industries)	1086	1516.868	5347.239	46.24
	1984/85				
a.	Aluminium	7	270.000	2285.00	96.61
b.	Chemicals	313	316.265	907.22	32.74
c.	Fertilizers	31	328.146	858.65	29.87
d.	Iron & Steel	17	623.400	2253.27	41.26
e.	Mineral Oil and Petroleum	29	289.219	1053.65	41.58
f.	Paper	117	273.423	838.15	34.99
g.	Sugar	272	632.414	1012.12	18.26
	Total (a to g)	786	2732.867	9208.06	38.46
	Total (All Industries)	3464	5038.059	12303.05	27.87

Source : CEA, op cit Ref. Table II.3.2.

II.3f Transmission and Distribution Network

The transmission and distribution sector faces several problems. Its expansion and strengthening has not kept pace with additions in generating capacity -- in certain instances, the utilization of generation capacity has been reduced simply because of poor reliability of the T/D network. This itself has aggravated power shortages in certain parts of the country. Furthermore, in the absence of regional or national integration of the T/D network, the power supplies cannot be optimized. Although the Rajyadhyaksha Committee (Government of India, 1980) had recommended that 50% of total power sector outlay should be earmarked for transmission/distribution facilities, actual investments during the Sixth and Seventh Five Year Plan periods have been about 38% only.

A high priority has been accorded only to the construction of high tension transmission lines of 400kV and 220kV. However, like for generation projects, there have been significant delays. During the period 1980/81 to 1986/87, the achievement in commissioning 400kV lines has been 30% short of target, and of 220kV lines, nearly 37% short.

Transmission and distribution losses have also increased steadily during the last decade. This aspect is discussed in section II.3g.

Table II.3.20: Transmission and Distribution Lines of Utilities -- As On March 31 of Each Year (Circuit Kilometres)

	1971	1974	1977	1980	1985
Northern Region	**301379**	**416467**	**508902**	**665188**	**931179**
- 400 kV	--	--	--	762	2483
- 220/230 kV	2745	3695	5558	8434	12279
- 132 kV	8789	10061	12659	15222	20189
- 11/15 kV	125804	168068	196727	250310	329555
Western Region	**249981**	**343876**	**441701**	**624377**	**879759**
- 400 kV	--	--	--	690	2968
- 220/230 kV	3188	4192	5796	9797	14417
- 132 kV	5661	9358	11125	13871	17288
- 11/15 kV	74517	106867	130938	176403	273592
Southern Region	**447268**	**601967**	**682583**	**797888**	**1039764**
- 400 kV	--	--	--	--	346
- 200/230 kV	4603	5247	6828	8121	11867
- 132 kV	3487	3856	3848	3599	5427
- 11/15 kV	112166	142165	159127	182943	235088
Eastern Region	**107230**	**138690**	**194188**	**234700**	**293372**
- 400 kV	--	--	--	--	236
- 200/230 kV	705	705	3231	3423	5402
- 132 kV	7857	7611	9069	9514	13167
- 11/15kV	36405	51797	77481	96683	121281
North Eastern Region	**11304**	**17884**	**22899**	**29456**	**67782**
- 400 kV	--	--	--	--	--
- 200/23o kV	--	93	93	257	532
- 132 kV	665	829	991	13	2572
- 11/15 kV	3543	6263	8048	10855	26799
All India	**1117162**	**1518884**	**1850273**	**2351609**	**3211956**
- 4oo kV	--	--	--	1452	6035
- 200/230 kV	11241	13932	21506	30032	44497
- 132 kV	26459	31715	37692	43591	58643
- 11/15 kV	352435	475160	572321	717194	986415

Source : CEA, op cit Ref. Table II.3.2.

Table II.3.21: Central Sector Transmission Lines in 1986 - 87

Transmission Line	Executing Agency	Length (ckt - kms)
400 kV Kanpur-Agra s/c	NTPC	242
400 kV Agra-Jaipur s/c	NTPC	257
400 kV Cuddapah-Bangalore s/c	NTPC	240
400 kV Koradi-Satpura s/c	NTPC	149
400 kV Satpura-Indore s/c	NTPC	294
400 kV Indore-Asoj s/c	NTPC	288
400 kV Neyveli-Salem s/c	NLC	175
220 kV Salal-Udhampur d/c	NHPC	42
Total		1687

s/c : Single Circuit.
d/c : Double Circuit.

Source : CMIE, op cit Ref. Table II.3.4.

Table II.3.22 : Major Transmission Works (Circuit Kms)

Year	400 kV			220 kV		
	Target	Achievement	Short fall (%)	Target	Achievement	Short fall (%)
1980/81	415	223	46.3	5445	3476	36.2
1981/82	1535	244	84.3	5454	2499	54.2
1982/83	2010	1126	44.0	4971	3876	22.0
1983/84	1933	826	57.3	5305	1849	65.0
1984/85	1574	1500	4.7	3120	3565	9.7
1985/86	2428	2335	3.8	3598	2601	27.7
1986/87	2060	2191(a)	(-)6.4	2707	1182(a)	56.3

(a) Relates to end-February, 1987.

Source : CMIE, op cit Ref. Table II.3.4.

II.3g Power Losses

T/D losses in all Indian utilities have increased, on an average, from 17.5% in 1970/71 to 21.7% in 1985/86, and there is as yet no sign of a reversal of this trend. The most important reason for high T/D losses is the lack of adequate investment in T/D systems. For instance, a downward revision of the T/D outlay for the Seventh FYP period from Rs.220,000 million (as recommended by the Working Group on Power) to Rs.90,000 million, resulted in shelving all T/D system improvement schemes. This is despite the fact that a 1% reduction in overall T/D losses is estimated to be equivalent to an addition of 380 MW of generating capacity or energy generation at Rs.0.5/kWh (Advisory Board on Energy, "The Energy Scene". New Delhi, 1986).

In fact, it is believed that there is significant scope for reducing losses in the high tension part of the T/D system also. However, the concerned utilities need to conduct detailed analyses before establishing priorities for reducing technical losses in their T/D networks. Likewise, means of reducing pilferage must also be reviewed.

In addition to T/D losses, the conversion losses in thermal power stations (which now comprise a major share of generating capacity) are also considerably high. A comparison of average efficiencies of thermal units in various states reveals the rather substantial scope for reducing power generation intensity. However, it is important to realize that this may be difficult to achieve as long as the thermal units are subject to frequent start-up and shut-down. Moreover, some of the older thermal units have boilers which are not designed to operate on high ash coals.

Table II.3.23: Energy Generated and Energy Losses in Utilities (GWh)

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
Net Energy Generated	52964.4	63073.6	82999.34	98132.11	121234.33	145209.36
Energy lost in Transmission and Distribution and Energy Unaccounted for	9306.5	12931.12	16446.33	20075.95	25643.94	31214.18
Energy Losses(%)	17.5	20.5	19.8	20.4	21.1	21.5

Source : CEA, op cit Ref. Table II.3.2.

Table II.3.24: Transmission and Distribution Losses of SEBs 1985/86 (%)

SEB/Department	T&D Losses inculding unaccounted commercial losses
Northern Region	
Haryana	19.84
Himachal Pradesh	20.22
Jammu & Kashmir	35.85
Punjab	18.82
Rajasthan	26.54
Uttar Pradesh	20.50
Chandigarh	18.90
Delhi	18.00
Western Region	
Gujarat	25.50
Madhya Pradesh	18.90
Maharashtra	14.51
Dadra & Nagar Haveli	16.00
Goa, Daman & Diu	20.43
Southern Region	
Andhra Pradesh	19.19
Karnataka	22.50
Kerala	24.60
Tamil Nadu	18.70
Lakshadweep	19.82
Pondicherry	18.00
Eastern Region	
Bihar	22.48
Orissa	23.00
Sikkim	18.20
West Bengal	23.13
Andaman & Nicobar	15.11
North Eastern Reagion	
Assam	19.98
Manipur	45.00
Meghalaya(a)	8.19
Nagaland	20.00
Tripura	30.50
Mizoram	43.63
All India (Utilities)	21.70

(a) The lower T&D loss figure in respect of Meghalaya is due to bulk sale of energy at HT level to neighbouring states.

Source : CMIE, op cit Ref. Table II.3.4.

Table II.3.25: State-Wise Efficiency of Coal Based Steam Thermal Stations in 1983/84

	Efficiency (%)	Energy Input (goe/kwh)*
Northern Region	**25.20**	**341.7**
Haryana	21.10	406.7
Himachal Pradesh	-	--
Jammu & Kashmir	12.10	707.5
Punjab	26.00	330.6
Rajasthan	26.60	323.1
Uttar Pradesh	22.50	381.8
Delhi	26.50	325.0
Central Sector	29.60	290.2
Western Region	**29.04**	**291.6**
Gujarat	28.10	306.2
Madhya Pradesh	28.50	301.1
Maharashtra	30.60	281.0
Central Sector	25.50	337.7
Southern Region	**27.60**	**312.0**
Andhra Pradesh	30.20	284.7
Tamil Nadu	26.70	321.3
Central Sector	25.10	342.3
Eastern Region	**24.4**	**352.2**
Bihar	23.10	372.2
Orissa	26.40	325.7
West Bengal	24.00	358.3
D.V.C.	25.00	343.5
Andaman & Nicobar	1.40	5953.8
North Eastern Region	**22.00**	**390.6**
Assam	22.00	390.6
All India	26.80	320.1

* 1 goe = 1 gram of oil equivalent = 10 kcal.

Source : CEA, op cit Ref. Table II.3.2.

II.3h Electricity Utilization

With the growth in the T/D network, there has been a rapid increase in the number of towns and villages electrified. While all urban areas are now electrified, a 100% rural electrification has been achieved only in a few states, such as Punjab, Haryana and Tamil Nadu. With an increase in rural electrification, there has been a steep increase in the number of pumpsets energized. This has certainly helped in raising agricultural productivity, but the power supply situation in urban areas has suffered. It is important to note that the power supply situation in urban areas has deteriorated even though relatively few rural households have obtained electricity connections.

Although both the number of consumers and the sanctioned/connected load have increased rather rapidly, the data base cannot be taken as indicative of future trends. This is because of long lead times in obtaining connections; as well as the fact that the actual connected load may often exceed the sanctioned load significantly.

Table II.3.26: Number Of Towns Electrified In Various Population Groups - As On March 31 Of Each Year

Population	1971(a)	1974(a)	1977(b)	1980(b)	1983(b)	1985(b)
< 5000	266	267	294	296	296	297
5000- 9999	844	846	820	820	820	820
10000-19999	819	819	987	987	987	987
20000-49999	518	518	652	652	652	652
50000-99999	139	139	219	219	219	219
> = 100000	107	107	151	151	151	151
Total	**2693**	**2696**	**3123**	**3125**	**3125**	**3126**

a. Towns in population groups as per 1961 census.
b. Towns in population groups as per 1971 census.

Source : CEA, op cit Ref. Table II.3.2.

Table II.3.27: Number Of Villages Electrified In Various Population Groups As On March 31st Of Each Year

Population Group	1971(a)	1974(a)	1977(b)	1980(b)	1983(b)	1985(b)	1987
< 500	31824	52664	72351	95253	140092	166677	N.A.
500 - 999	26668	42462	54053	67650	86596	99189	N.A.
1000 - 1999	25887	34994	45150	53381	61864	67587	N.A.
2000 - 4999	17168	21633	25915	27938	29677	31168	N.A.
5000 - 9999	2688	3198	4118	4283	4355	4400	N.A.
> = 10000	704	763	1256	1294	1297	1311	N.A.
Total	**104939**	**155714**	**202843**	**249799**	**323881**	**370332**	**402647**

a. Villages in population groups as per 1961 census.
b. Villages in population groups as per 1971 census.

Source : CEA, op cit Ref . Table II.3.2.

Table II.3.28: Number Of Consumers And Connected Load - As On March 31 Of Each Year

	1971	1974	1977	1980	1985
Domestic					
- no. of consumers('000)	10165.2	13238.2	16288.5	20375.1	30723.9
- connected load (MW)	5985.9	7927.0	9557.6	11716.1	18922.7
Commercial					
- no. of consumers('000)	2305.7	2871.0	3494.0	4277.3	5882.7
- connected load (MW)	1911.0	2565.8	3797.4	4194.4	5820.1
Industrial (LV & MV)					
- no. of consumers('000)	532.3	713.4	842.3	1051.2	1508.3
- connected load (MW)	4560.6	5558.0	7902.5	9019.9	15473.7
Industrial (HV)					
- no. of consumers('000)	10.0	11.8	16.1	22.2	20.2
- connected load (MW)	6383.6	8503.8	10608.9	13600.9	15865.9
Public Lighting					
- no. of consumers('000)	58.3	162.1	120.6	129.3	180.9
- connected load (MW)	167.7	237.6	277.2	305.5	434.2
Traction					
- no. of consumers('000)	69.0	40.0	49.0	60.0	110.0
- connected load (MW)	417.7	603.8	741.5	783.4	991.0
Agriculture					
- no. of consumers('000)	1570.9	2391.1	3020.9	3880.5	5588.5
- connected load (MW)	6224.8	9494.2	12053.0	15247.4	21255.2
Public Water Works Sewage					
- no. of consumers('000)	10.2	20.0	26.4	35.5	64.5
- connected load (MW)	269.7	410.3	552.5	650.8	1077.0
Miscellaneous					
- no. of consumers('000)	12.2	20.9	30.2	57.2	666.6
-connected load (MW)	309.0	308.4	380.0	605.2	1394.0
Total					
- no. of consumers('000)	14665.0	19428.5	23839.0	29828.2	44636.0
- connected load (MW)	26230.2	35608.9	45870.7	56123.4	81234.3

Source : CEA, op cit Ref. Table II.3.2.

Table II.3.29: Trends In Village Electrification And Pumpset Energisation

Year	Villages Electrified: Number	Villages Electrified: As a % of total no. of villages	Pumpsets Energised. (Number)
1950/51	3,061	0.5	21,008
1955/56	7,294	1.3	56,058
1960/61	21,754	3.8	1,98,904
1965/66	45,148	7.8	5,12,756
1968/69	73,739	12.8	10,88,804
1973/74	1,56,729	27.2	24,26,133
1977/78	2,16,863	37.6	32,99,901
1978/79	2,32,770	40.4	35,98,775
1979/80	2,49,799	43.4	39,65,828
1980/81	2,72,625	47.3	43,30,437
1981/82	2,96,511	51.5	46,59,033
1982/83	3,23,881	56.2	49,73,268
1983/84	3,47,561	60.3	53,08,666
1984/85	3,70,332	64.3	57,08,563
1985/86	3,90,294	67.7	61,51,975
1986/87(a)	4,02,647	69.9	64,79,162

a. January end '87.

Source : CMIE, op cit Ref. Table II.3.4.

Table II.3.30: Peak Demand

	Month in which Demand was Max.	Actual Peak Demand *(MW)
A. 1978/79		
Northern	January	4691
Western	December	4486
Southern	November	4004
Eastern	August	2240
North-Eastern	September	158
All India **	---	15579
B. 1980/81		
Northern	January	5015
Western	January	5442
Southern	November	4425
Eastern	February	2429
North Eastern	March	189
All India **	---	17500
C. 1982/83		
Northern	January	5767
Western	February	6200
Southern	August	5419
Eastern	October	2861
North Eastern	November	298
All India **		20545
D. 1983/84		
Northern	March	5974
Western	December	6977
Southern	N.A.	5872
Eastern	March	2831
North Eastern	December	318
All India **	---	21972
E. 1984/85		
Northern	December	6366
Western	March	7719
Southern	December	6596
Eastern	March	3001
North Eastern	October	338
All India **	---	24020

* Figures for peak demand are of actual simultaneous peak demand on the regional system, irrespective of power restrictions.

** Non coincident aggregate.

Source : CEA, op cit Ref. Table II.3.2.

II.4 BIOMASS

II.4a Introduction

Biomass comprises all forms of matter derived from biological activities, and is present either on the soil surface, or at various depths of the vast body of water-lakes, streams, rivers, seas and oceans. However, the biomass of immediate concern is that growing above ground. Biomass, though abundant in India, is a scattered resource. With an increase in agricultural productivity, human and livestock population, and urbanization and industrial output, the production of waste materials (that may be used as a source of energy) has increased. The data base in this area is however, very deficient. The data available are usually "normative" rather than actual -- although the norms themselves may be derived from some isolated sample surveys.

There is therefore a need to assess the availability of residues, their method of collection and storage, their chemical composition, calorific content and other characteristics, environmental implications of their utilization, and so forth. Only with such an overall assessment will it be possible to formulate an appropriate policy for biomass utilization.

The availability of biomass is related to the land utilization pattern. Some aggregate land utilization data are presented below.

Table II.4.1: Land Utilization(1976/77)
(million hectares)

a.	Total Geographical Area	328
b.	Area under forest	75
c.	Area not available for cultivation	39
c1	Barren and unculturable lands	21
c2	Land put to non-agricultural uses	18
d.	Other uncultivated land excluding current fallow	34
e.	Fallow lands	22
f.	Area under agriculture (net sown area)	143

b. Includes all lands classified as forests under any legal enactment dealing with forests or administered as forests, whether state-owned or private, and whether wooded or maintained as potential forest land.

c1. Includes mountains, deserts etc. Land which cannot be brought under cultivation unless at a high cost are classified as unculturable, whether such land is in isolated blocks or within cultivated holdings.

c2. Includes all land occupied by buildings, roads and railways or under water (e.g. rivers, canals, lakes etc.), as well as other land put to uses other than agriculture.

d. Includes: (i) permanent pastures and other grazing lands; (ii) all cultivated land not included in net sown area, but used for planting miscellaneous crops (casurina, thatching grass, bamboo bushes) and groves for fuel etc. which are not classified as orchards; and (iii) land cultivated earlier but not for at least five years in succession.

e. Includes land kept fallow in the current year but not for more than five years in succession.

f. Area sown with crops and orchards, counting areas sown more than once in the same year only once.

Source: Ministry of Agriculture, GOI, 1974/75 to 1976/77, Indian Agricultural Statistics, Directorate of Economics and Statistics.

II.4b Forestry

According to the National Forest Policy (1952), 33% of the total land area, or around 100 million hectares (mha) of land should be under forest cover. However, the forest cover is still much less; the forests are scattered and several parts of the country have no forests at all.

According to one set of estimates, about 4.5 mha of forest area were clear-felled between 1947 and 1967. This represents an average annual loss of about 150,000 hectares. However, these figures may represent only the authorized encroachment of land for extending agriculture, and for establishing industries and other development projects. A large portion of forest area is being denuded also because of excessive use, resulting in loss of productivity. It is estimated that over 5 mha of forest area is under shifting cultivation, and the capacity of these lands for producing forestry goods and services is severely limited. It is for such reasons that the Government has undertaken a large programme of afforestation, social forestry and farm forestry.

According to A. Singh (The National Forest Cover Monitoring Using Satellite Imagery, The Indian Forester, Vol. 112, No. 6, pp 477-484), the data base on India's forest cover is very inadequate, and a more appropriate system of classification should be adopted, based on crown density and stand height.

Table II.4.2: Classification of Total Forest Area*
('000 sq km)

Year	Total Forest Area	By composition: Coniferous	Non-Coniferous	By types: Merchantable	Unprofitable or inaccessable
1951/52	734.4	34	700.4	554.9	179.5
1955/56	703.6	25.2	678.4	564.9	138.7
1960/61	689.5	44.3	645.2	529.4	160.1
1965/66	751.9(a)	46.7	699.0	594.1	151.6
1970/71	747.7(a)	39.2	699.2	577.4	161.0
1975/76	747.3(b)	47.4	634.1	585.7	161.6
1976/77(p)	750.4(b)	40.5	692.1	565.9	173.9
1977/78(p)	747.6(b)	39.9	689.4	565.8	170.8
1978/79(p)	747.4(b)	47.7	681.3	565.9	170.4
1979/80(p)	736.6(b)	47.6	670.3	564.9	160.4

* Area under forest departments.
p. Provisional.
a. Includes 6212 sq km in 1965-66 and 8566 sq km in 1970-71 for want of legal classification.
b. Also includes forest area which is not accounted for due to want of details.

Source: Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1984.

Table II.4.3: Total Forest Area by Type of Legal Status*
('000 sq km)

Year	Reserved	Protected	Unclassed
1951/52	344.8	152.0	237.5
1955/56	359.4	168.5	170.2
1960/61	316.1	240.5	112.1
1965/66	348.4	249.3	127.7
1970/71	360.2	212.7	115.1
1975/76	389.7	231.9	125.8
1976/77(p)	363.9	236.6	119.0
1977/78(p)	367.6	236.3	112.4
1978/79(p)	373.6	232.9	107.9
1979/80(p)	372.5	225.3	105.6

* Area under forest departments.
p. Provisional.

Source: CSO, op cit Ref. Table II.4.2.

Table II.4.4: Progress of Forest Regeneration and Afforestation (sq km)

Year	Area regenerated: By natural regeneration in existing tree forests	By coppice	By artificial regeneration: In existing tree forests	By artificial regeneration: Afforested	Total area regenrated and afforested
1950/51	8000	2082	653	171	10906
1955/56	4496	2445	697	264	7902
1960/61	4445	4890	2955	660	12970
1965/66	7601	2760	3341	8439	22128
1970/71	13644	3129	762	944	19088
1975/76	8982	33784	---	1628	44394
1976/77(p)	7876	52847	---	2132	62855
1978/79(p,a)	8106	1957	12844	25020	47927
1978/79(p,a)	8359	1347	18571	11142	39419
1979/80(p,b)	10180	817	1059	1605	13661

p. Provisional.

a. Excludes the states of Assam, Goa, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Orissa, Sikkim, West Bengal and the union territories of--Arunanchal Pradesh, D & N Haveli, Delhi, Daman and Diu and Mizoram for which the data are not available.

b. Excludes the states of Assam, Bihar, Goa, Haryana, Jammu & Kashmir, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Tripura, West Bengal and union territories of Arunachal Pradesh, D & N Haveli, Delhi, Daman and Diu and Mizoram for which the data are not available.

Source: CSO, op cit Ref. Table II.4.2.

Table II.4.5: Year-Wise Achievements/Targets Under Afforestations, Social and Farm Forestry During Sixth Plan (seedlings to be planted in lakhs)

	Achievements							Targets	
	1980/81		1981/82		1982/83		1983/84 Upto Oct'83		
	A	S	A	S	A	S		1983/84	1984/85
Major States									
Andhra Pradesh	410	65	680	65	1243	65	1200	1620	1800
Bihar	371	80	554	88	901	86	1069	1075	1200
Gujarat	928	76	1494	75	2468	80	2750	2680	3000
Haryana	309	70	600	75	760	75	900	1000	1000
Karnataka	559	64	141	68	1768	75	1950	2250	2500
Kerala	142	75	162	76	619	75	597	550	600
Madhya Pradesh	1099	81.3	2456	81	2839	81.3	2500	2875	3200
Maharashtra	626	68.5	874	71	2276	75	1796	1400	1550
Orissa	518	50	607	50	1038	50	734	1000	1050
Punjab	175	65	373	72	547	75	600	800	700
Rajasthan	209	73.9	305	80	368	75	68	70	80
Tamil Nadu	819	73-82	817	73-82	1024	73-82	537	1000	1050
Uttar Pradesh	1050	83.6	1052	83	2305	80.7	3250	2950	3300
West Bengal	276	95	430	95	677	95	650	750	1150
All India	8467		13188		20785		20773	22500	25000

A Achievements.
S Survival Percentage.

Source: GOI, India's Forests, 1984.

Table II.4.6: Major Produce of Forests
('000 cubic metres)

Year	Timber(a)	Pulp and match wood (b)	Firewood(c)	Total
1951/52	2820	1162	10710	14692
1955/56	3395	763	10810	14967
1960/61	4593	833	11642	17094(d)
1965/66	N.A.	693	13619	20554
1970/71	N.A.	9655	12090	21745
1975/76	N.A.	10772	15122	25894
1976/77 (P)	N.A.	8185	12412	20597
1977/78 (P)	N.A.	8303	14702	23005
1978/79 (P)	N.A.	7966	14304	22270
1979/80 (P)	N.A.	7561	13920	21481

P. Provisional.

a. Data on timber is included in pulp and match wood from 1965-66 onwards, since item-wise breakup is not available.

b. Includes data on round wood.

c. Includes charcoal wood.

d. Includes 25000 cubic metres for which details are not available.

Source: CSO, op cit Ref. Table II.4.2.

Table II.4.7: Per capita Wood Production in 1980 --- International Comparison (cubic metres)

	Roundwood(a)	Industrial wood(b)	Fuelwood(c)
India	0.322	0.029	0.294
China	0.223	0.068	0.155
Indonesia	0.897	0.163	0.734
Japan	0.296	0.291	0.005
Turkey	0.499	0.137	0.361

a. Includes industrial wood and fuelwood.

b. Includes industrial round wood, comprising saw logs, veneer logs, pulpwood, timber and other industrial wood.

c. Includes wood in branches and twigs, wood in tree trunks used as fuel, and wood used for charcoal production.

Source: A.K. Mahendra and G.P. Maithani, Forest Production in India vis-a-vis other Asian Countries, The Indian Forester, Vol. 112, No.12, Dec.1986, pp 1058-1066.

II.4c Crop Residues

Several renewable resources are abundantly available in the agro-processing centres, such as rice husk, bagasse, molasses, coconut shell, groundnut shell, maize cobs, potato waste, coffee waste and so forth. Likewise, organic residues such as rice straw, wheat straw, cotton sticks, jute sticks etc. are also available on farms. Such resources may be used as fuel, and in fact may be suited for several other applications also.

Agricultural commodities may be processed at the family level, in small processing units or modern mills. Therefore, the quantity and quality of residues available at each site, depends not only upon the specific agro-climatic conditions of a region, but also on the scale and efficiency of the processing unit.

The data-base on the availability of crop residues is very inadequate. However, some estimates based on normative residue-to-crop yield ratios are presented. The same ratios are used to estimate the residue yield during the time period

1950/51 to 1983/84, for want of better estimates; although this may not be correct. For instance, grain yield of bajra (pearl millet) may vary from 3 to 4 tonnes/hectare, and the straw yield from 1.2 to 9 tonnes/hectare, depending on whether the crop is grown in an irrigated area or not, whether high yielding variety seeds are used or not, and several other factors such as type of soil, sunshine hours, fertilizer usage pattern etc. As at least the first two factors have changed substantially over the past two decades or so, it is clear that the estimates presented in Table II.4.8 are very tentative.

Crop residues may be utilized as fuel, fertilizer, feed, as well as building material, industrial material and in chemical formulations. However, in view of the need for decentralized energy supply for agro-industrial processing and for rural homes, their use as fuel is of primary importance. For example, rice husk is used to supply energy for rice milling and tobacco curing, as also in the brick industry. Similarly bagasse, which is an important by-product of the sugar industry, is used entirely in the sugar industry itself, either as boiler fuel to generate steam, or for boiling and concentrating sugarcane juice. Likewise, coconut shell which has been used traditionally as fuel for copra kilns, lime kilns and brick kilns, can also be used to yield gas, charcoal, acetic acid, wood spirit and phenol through destructive distillation.

Table II.4.8: Potential Availability of Agriculture Based Biomass

	1950/51	1960/61	1970/71	1981/82	1982/83	1983/84
A. Potential Availability of Rice Husk						
- Cropped Area ('000 hectares)	30810	34128	37592	40708	38262	40990
- Rice Production ('000 tonnes)	20576	34574	42225	53248	47116	59768
- Rice Husk Availability ('000 tonnes)	10288	17287	21112	26624	23558	29884
B. Potential Availability of wheat Straw						
- Cropped Area ('000 hectares)	9746	12927	18241	22144	23567	24395
- Wheat Production ('000 tonnes)	6462	10997	23832	37452	42794	45148
- Wheat Straw Availability ('000 tonnes)	8594	14626	31696	49811	56916	60047
C. Potential Availability of Maize Cobs						
- Cropped Area ('000 hectares)	3159	4407	5852	5935	5720	5888
- Maize Production ('000 tonnes)	1729	4080	7486	6897	6548	7924
- Cob Availability ('000 tonnes)	519	1224	2246	2069	1964	2377
D. Potential Availability of Bajra Straw						
- Cropped Area ('000 hectares)	9023	11469	12913	11784	10942	11810
- Bajra Production ('000 tonnes)	2595	3283	8029	5537	5131	7624
- Straw Availability ('000 tonnes)	4308	5450	13328	9191	8517	12656

	1950/51	1960/61	1970/71	1981/82	1982/83	1983/84
E. Potential Availability of Ragi Straw						
- Cropped Area ('000 hectares)	2203	2515	2472	2611	2412	2601
- Ragi Production ('000 tonnes)	1429	1838	2155	2961	2223	2991
- Straw Availability ('000 tonnes)	6859	8822	10344	14213	10670	14357
F. Potential Availability of Small Millet Straw						
- Cropped Area ('000 hectares)	4605	4955	4783	3786	3499	3612
- Millet Production ('000 tonnes)	1750	1909	1988	1638	1229	1712
- Straw Availability ('000 tonnes)	4462	4868	5069	4177	3134	4365
G. Potential Availability of Bagasse						
- Cropped Area ('000 hectares)	1707	2415	2615	3193	3358	3166
- Sugarcane Production ('000 tonnes)	57051	110001	126368	186358	189506	177020
- Bagasse Availability ('000 tonnes)	19017	36667	42122	62119	63168	59006
H. Potential Availability of Coconut Shell, Fibre and Pith						
- Cropped Area ('000 hectares)	622	717	1046	1091	1113	---
- Coconut Productuib (million nuts)	3582	4639	6075	5573	5664	---
- Shell Availability ('000 tonnes)	483	626	820	752	764	---

	1950/51	1960/61	1970/71	1981/82	1982/83	1983/84
- Fibre Availability ('000 tonnes)	587	761	996	914	929	---
- Pith Availability ('000 tonnes)	881	1141	1494	1371	1393	---
I. Potential Availability of Ground - nut Shell						
- Cropped Area ('000 hectares)	4494	6463	7326	7429	7215	7640
- Groundnut Production ('000 tonnes)	3481	4812	6111	7223	5282	7284
- Shell Availability ('000 tonnes)	1160	1604	2037	2407	1760	2428
J. Potential Availability of Cotton Stalks						
- Cropped Area ('000 hectares)	5882	7610	7605	8057	7871	7765
- Cotton Production ('000 bales of 170 Kg)	3044	5604	4763	7884	7534	6582
- Cotton Stalks Availability ('000 tonnes)	17646	22830	22815	24171	23613	23295
K. Potential Availability of Jute Sticks						
- Cropped Area ('000 tonnes)	571	629	749	826	734	741
- Jute Production ('000 bales of 180 Kg)	3309	4134	4938	6788	5946	6057
- Jute Sticks Availability ('000 tonnes)	1713	1887	2247	2478	2202	2223

A. Rice Husk	:	0.5 by weight of clean rice.
B. Wheat Straw	:	1.33 by weight of wheat grain.
C. Maize Cobs	:	0.3 by weight of maize grain.
D. Bajra Straw	:	1.66 by weight of bajra gain.
E. Ragi Straw	:	4.8 by weight of ragi.
F. Small Millets	:	2.55 by weight of millets.
G. Bagasse	:	0.33 by weight of sugarcane.
H. Cocónut Shell, Fibre Pith	:	1 coconut yields 135g shell, 164g fibre and 246g pith.
I. Groundnut Shell	:	0.33 by weight of groundnut produced.
J. Cotton Stalks	:	3 tonnes of cotton stalks produced per hectare.
K. Jute Sticks	:	3 tonnes of jute sticks produced per hectare.

Source : (i) CSO, op cit Ref. Table II.4.2; (ii) The source for potential availability of rice husk is Fertilizer Association of India, Fertilzer Statistics, 1983-84; (iii) For wheat, bajra, ragi and small millets: ICAR, Handbook of Agriculture; (iv) For maize cobs, bagasae, groundnut shell, cotton stalks and jute sticks: O.P. Vimal and P.D. Tyagi, Energy From Biomass, Agricole Publishing Academy, New Delhi, 1984; and (v) For coconut shell, fiber and pith: TERI Report on 'Potential for Renewable Energy Utilization in Andaman & Nicobar and Lakshadweep Islands', Prepared for DNES.

II.4d Animal Wastes

Dung, poultry excreta etc. are available in abundance in animal sheds, poultry farms etc. The quantity of waste available of course, depends on the weight and age of animals. It may vary from 0.04 kg/day in case of hens to 15 kg/day from buffaloes. However, not all dung that is available may be collected; and not all dung that is collected, may in fact be used as fuel. The utilization rate in a particular area depends upon the climate and fuelwood availability; and also varies with season.

With an increase in livestock population since the early 1950s, the availability of animal wastes may be considered to have increased significantly during the past four decades. Little data however, are available on its method of collection and utilization, except from some sample surveys (in which actual measurements were not made).

Table II.4.9 : Livestock Population ('000)

	1951	1956	1961	1966	1972	1977
Cattles	155295	158669	175557	176186	178341	180140
Buffaloes	43400	44948	51210	52955	57426	62029
Sheep	39052	39259	40223	42015	39993	40907
Goats	47155	55449	60864	64588	67518	75620
Horses & Ponies	1515	1484	1327	1149	942	916
Other Livestock	6367	6804	7251	7222	9118	9928
Total	292784	306615	336432	344111	353338	369540

Source: CSO, op cit Ref. Table II.4.2.

Table II.4.10: Dung Production in Various States (Kg/bovine/day)

Andhra Pradesh	3.6
Bihar	3.6
Gujarat	3.7
Haryana	6.8
Himachal Pradesh	5.3
Katnataka	2.9
Kerala	2.6
Madhya Pradesh *	2.6
Maharastra	3.2
Punjab	7.0
Rajasthan **	5.7
Tamil Nadu	5.8
Uttar Pradesh	4.7

* Estimates based on surveys covering only western parts of the State.

** Estimates based on surveys covering only about 2/3 of the State.

Source: Goel BBPS et al, Indian Journal of Animal Science, 1973, 43; as quoted in Vimal and Tyagi, Energy Form Biomass, Agricole Publishing Academy, New Delhi, 1984.

II.4e City Wastes

Garbage or municipal solid waste, which is considered to be a potent source of environmental pollution, can meet a significant portion of urban energy needs if tapped efficiently. The traditional practice of using it as a land-fill, may not be the best way of utilizing it, not only because it is insanitary and malodorous, but also because it gets putrified gradually, and the liquids seep into the soil and ultimately pollute the ground water reservoirs.

Although the city wastes in India are only about 0.4 kg per day per city dweller (compared to 1 kg in Japan and about 2 kg in USA), the total quantities in India are very large. As about 60% of the waste is non-compostable, the problem is quite serious, and the quantity of putrescibles is significantly higher than in the European countries.

Any changes in the existing patterns of waste disposal or utilization may be made rationally only if there is adequate knowledge of its physical and chemical characteristics. The information collected through a detailed survey of Bombay city is summarized below.

Table II.4.11: Potential Availability of City Refuse

		City Refuse (million tonnes/year)		
	Urban Population (million)	Total(a)	Non-Compostable	Compostable(b)
1970/71	110.2	16.09	9.65	6.44
1975/76	134.5	19.64	11.78	7.86
1980/81	157.7	23.02	13.81	9.21

a. 0.4 kg/urban dwellers/day (Vimal and Tygai, 1984).

b. 60% is non-compostable; 40% is compostable (Vimal & Tyagi, 1984).

TableII.4.12: Chemical Characteristics of City Refuse

	Population Range of City (millions)			
	< 0.2	0.2 - 0.5	0.5 - 0.2	> 2.0
Moisture(%)	22.12	25.05	22.45	31.18
pH	8.18	8.16	8.34	7.68
Organic Matter (%)*	22.02	22.51	21.51	27.57
Carbon (%)*	12.26	12.51	11.95	15.32
Nitrogen (%)*	0.6	0.61	0.56	0.58
Phosphorous (P_2O_5) (%)*	0.71	0.72	0.68	0.59
Potash (K_2O) (%)*	0.71	0.74	0.72	0.68
Calorific Value (Kcal/Kg)	801	874	867	1140

* On a dry weight basis.

Source: Bhide et al. India Journal of Enviromental Health, 1973, 17(3), as quoted in Vimal and Tyagi, Energy from Biomass, Agricole Publishing Academy, New Delhi, 1984.

Table. II.4.13: Physical Characteristics of City Refuse in Bombay

	Minimum (%)	Maximum (%)
Leaves, Flowers	0.90	42.08
Fruit, Vegetable matter	0.86	72.60
Hay, Straw	0.40	20.73
Coconut	0.76	40.00
Paper etc.	0.30	20.57
Rubber, Leather	0.19	5.05
Plastics	0.16	8.15
Rags	0.15	48.60
Wooden matter	0.20	10.72
Coal	0.15	3.97
Ferrous metal	0.05	0.98
Non-Ferrous metal	0.11	1.87
Glass	0.10	2.25
Crockery	0.12	8.04
Bones, Earthenware	0.21	7.60
Ash, Fine Earth	2.68	56.99
Stone, Bricks	0.42	27.41
Fine Organic matter	5.00	62.27

a. All the values are given in percentage and calculated on wet weight basis.

b. Refuse was collected from 59 sampling points in Bombay from 20th - 30th September, 1984.

Source: National Environmental Engineering Research Institute, Report on 'Characterisation of Bombay City Refuse', Prepared for Municipal Corporation of Greater Bombay, September 1985.

Table II.4.14: Chemical Characteristics of City Refuse in Bombay

	Minimum	Maximum
Moisture (%)	13.33	84.0
PH Value	5.3	8.1
Organic Matter * (%)	30.02	84.4
Carbon * (%)	14.35	43.2
Nitrogen * (%)	0.29	1.3
Phosphorous * (P_2O_5) (%)	0.37	1.14
Potash * (K_2O) (%)	0.17	2.01
C/N Ratio	22.83	65.84
HCV (Kcal/Kg)	913	4372

* All values are calculated on dry weight basis Refuse was collected from 59 sampling points in Bombay from 20th - 30th September, 1984.

Source: National Environmental Engineering Research Instiute, op cit Ref. Table II.4.13.

III. ENERGY DEMAND

III.1 Overview

In trying to identify the determinants of energy demand, economists have studied several issues, including the level of economic development, relative energy consumption levels in the various economic sectors and sub-sectors, major energy consuming activities in a particular sector, type/vintage/cost/other characteristics of energy consuming equipment in use, energy prices, and so on.

To get a good feel of the energy demand aspects obviously entails very large data base requirements. Such data are not usually compiled systematically in developing countries, including India. However, an attempt is made here to present energy and related data for major energy consuming activities in sections III.2 through III.6.

Background data on the composition of India's gross domestic product (GDP), population, energy imports and per-capita commercial energy consumption are also presented. It may be noted that although the commercial energy consumption per-capita has increased gradually since the early 1970s, it still remains at less than 10% of the levels achieved in the industrialized market economies. Even if the contribution of traditional energy forms is considered, the total energy consumption per-capita remains far below the levels of the industrialized nations.

Table III.1.1: GDP at Factor Cost By Industry of Origin (Rs. million, 1970/71 Prices)

	1970/71	1975/76	1980/81	1982/83	1984/85
a. Agriculture, forestry & logging, mining & quarrying	178020	199340	210150	213420	236440
b. Manufacturing, Construction, Electricity, Gas & Water Supply	75940	87820	109370	120910	133660
c. Transport, Communication & Trade	59120	74610	95540	109420	121870
d. Banking & Insurance, Real Estate & Ownership of Dwellings & Business Services	21140	25740	33580	38410	43630
e. Public Administration, Defence & Other Services	33140	41390	57590	68520	82780
f. Total	367360	428900	506230	550680	618380

Source: Central Statistical Organisation, National Accounts Statistics, various issues.

Table III.1.2: Population and Trends in Urbanization

	Total Population (million)*	Urban Population %
1950	359	17.3
1960	434	18.0
1970	541	19.9
1980	679	23.7
1986	771	---

* As on September 1.

Source: Centre for Monitoring Indian Economy, Basic Statistics Relating to the Indian Economy, vol. 1: All India, Bombay, August 1987.

Table III.1.3: Net Imports of Crude Oil and Petroleum Products

	Net Imports of Crude Oil and Petr. Products ('000 tonnes)	As a % of total Imports	As a % of total Exports
1970/71	12435	8.1	8.6
1975/76	15672	23.6	30.8
1976/77	16598	27.9	27.6
1977/78	17339	25.7	28.6
1978/79	18491	24.6	29.3
1979/80	20757	35.5	50.6
1980/81	23501	41.9	78.4
1981/82	19289	36.6	63.8
1982/83	16630	30.8	50.0
1983/84	13301	20.5	32.7
1984/85	12323	21.4	31.2
1985/86 *	16518	23.5	41.4

* Provisional.

Source: Ministry of Petroleum and Natural Gas, Indian Petroleum and Natural Gas statistics, 1985-86.

Table III.1.4: Per-capita Consumption of Commercial Energy (toe)

1970/71	0.094
1973/74	0.114
1979/80	0.107
1982/83	0.113
1985/86	0.122

III.2 AGRICULTURE

III.2a Introduction

Agricultural productivity, and hence value added, depend upon several factors including the area of land under cultivation, extent of multiple cropping, the choice of crop, use of high yielding varieties, use of organic and inorganic fertilizers, the coverage of surface and ground-water irrigation schemes, the extent of mechanization for land preparation and so forth.

Although over 60% of India's economically active population is engaged in agriculture, the share of gross value added from this sector to total GDP, has centred around 36% over the past seven to eight years.

India ranks second, next only to the USSR, as far as the total arable land area is concerned. However, on a per-capita basis, the arable land area of 0.24 hectares in India is just about half of the average of 0.47 hectares for the 22 selected countries (Table III.2.1).

The consumption of inorganic fertilizers in India in 1982/83 was only 39.4 kg/hectare of arable land. In Japan, it was as high as 437 kg. In most countries other than Burma, Brazil and the Philippines, inorganic fertilizer consumption seems to be more intensive than in India. Therefore, there seems to be a substantial scope for increasing agricultural output in India. This becomes clear from a comparison of yield/hectare of major rice and wheat growing countries.

Another interesting feature about Indian agriculture is the increase in the number of land holdings. However, the area under agriculture has remained more or less unchanged at around 162 million hectares, for at least two decades. Therefore, this increase in the number of land holdings is the outcome of a "downward compression of peasantry", which is marked by division and re-division of the erstwhile large holdings.

Table III.2.1 : Agricultural Indicators -- An International Comparison**

	Economically active population in agriculture as % of total	Arable Land* (million hectares)	Per Capita Arable Land* (hectares)	Fertilizer Consumption per hectare of arable land* (kg)
India	61	169.5	0.24	39.4
Bangladesh	83	9.1	0.10	59.6
China	57	100.9	0.10	180.6
Pakistan	52	20.3	0.22	58.6
Sri Lanka	52	2.2	0.14	71.3
Burma	50	10.1	0.27	16.7
Egypt	49	2.5	0.06	360.5
Philippines	44	11.8	0.23	32.0
Brazil	36	74.7	0.58	36.5
Iran	36	13.7	0.34	65.6
Korea, Rep	35	2.2	0.05	345.2
Mexico	34	23.5	0.32	61.2
U.S.S.R.	15	232.3	0.86	98.7
Italy	10	12.4	0.22	168.9
Japan	9	4.8	0.04	437.0
France	8	18.6	0.34	311.6
Israel	6	0.4	0.10	183.1
Canada	4	46.2	1.87	48.7
Germany, W.	3	7.5	0.12	421.1
U.K.	2	7.0	0.12	374.6
U.S.A.	2	190.6	0.82	104.5

* : Including area under permanent crops.
** : Data relate to 1982 or 1983.

Source : Department of Economics & Statistics (Tata Services Ltd.), Statistical Outline of India, 1986-87, June 1986.

Table III.2.2 : Value Added From Agriculture and Allied Activities (Rs. million 1970/71 prices)

		970/71	1975/76	1980/81	1981/82	1982/83	1983/84
a.	Value of output	207295.0	232126.2	252230.3	263165.7	257005.8	280875.2
a1	Agriculture	175309.5	193725.5	207520.8	217569.6	210102.3	232554.4
a2	Livestock *	31985.5	38400.7	44709.5	45596.1	46903.5	48320.8
b.	Inputs	40885.8	48242.4	57659.9	60650.0	61746.6	64986.3
c.	Gross Value Added in agriculture and allied activities	166409.2	183883.8	194570.4	202510.7	195259.2	215888.9
d.	Gross Value Added to GDP (%)	45.3	43.1	38.4	37.9	35.5	36.4

* Includes value of output from hunting and trapping.

Source : Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, various issues.

Table III.2.3 : Output and Yield of Rice in 1983 *

	Yield (100 kg/hectare)	Share of output in total world production ** (%)
India	22.0	20.0
Japan	57.0	2.9
U.S.A.	51.5	1.0
China	50.7	38.3
Indonesia	37.7	7.6
Burma	30.9	3.2
Philippines	24.7	1.8
Vietnam	24.6	3.2
Bangladesh	20.5	4.8
Thailand	19.7	4.1

* Relates to output and yield of major rice producing countries.

** The total world production of rice in 1983 was 449.8 million tonnes.

Source : Tata Services Ltd., op cit Ref. Table III.2.1.

Table III.2.4 : Output and Yield of Wheat in 1983*

	Yield (100 kg/hectare)	Share of output in total world production ** (%)
India	18.4	8.5
France	51.3	5.0
China	28.3	16.3
U.S.A.	26.5	13.3
Canada	19.7	5.4
Turkey	18.6	3.3
Australia	17.2	4.4
Argentina	17.1	2.3
Pakistan	16.8	2.5
U.S.S.R.	16.1	16.5

* Relates to output and yield of major wheat producing countries.

** The total world production of wheat in 1983 was 498.2 million tonnes.

Source : Tata Services Ltd., op cit Ref. Table III.2.1.

Table III.2.5 : Number and Area of Operational Holdings

Size Range (Hectares)	No. of Holdings (million)			Area of Holdings (million hectares)		
	1970/71	1976/77	1980/81	1970/71	1976/77	1980/81
Marginal Below 1	36.20	44.52	50.52	14.56	17.51	19.80
Small 1-2	13.43	14.73	16.08	19.28	20.91	22.96
Medium 2-10	18.61	19.88	20.60	78.24	82.05	82.90
Large 10 & above	2.77	2.44	2.15	50.06	42.87	37.13
Total	71.01	81.57	89.35	162.14	163.34	162.79

Source : Tata Services Ltd., op cit Ref. Table III.2.1.

III.2b Cropped and Irrigated Area

The net sown area increased from 119.4 million hectares (mha) in 1951/52 to 141.8 mha in 1982/83, at an average growth rate of about 0.5% per annum. During the same time period, gross cropped area increased from 133.2 mha to 172 mha, at the rate of 0.8% per annum. The relatively faster growth of agricultural productivity was a result of a rise in irrigation facilities, which made multiple cropping possible on a larger portion of the cultivated land area. It may be noted, that during the 31 year time period 1951/52 to 1982/83, the shares of net and gross irrigated areas, to net sown and gross cropped areas respectively, also increased significantly.

Crops may be irrigated either through surface water sources (canals, rivers, ponds etc.) or by pumping ground water. Since the 1950s, there has been a sharp increase in the share of land area irrigated by lifting ground water. This may be due not only to the fact that the Rural Electrification Corporation (REC) has made a concerted effort to energize pumpsets in rural areas, but also because the gestation lag of lift irrigation schemes are much smaller than those of large surface irrigation schemes. Furthermore, farmers may also prefer pumpsets, because of their relatively higher reliability -- because water becomes available when needed. In fact, owing to insufficient electricity supplies, certain farmers have also installed diesel pumpsets for standby use.

Owing to an increase in assured irrigation supplies, the cultivation of high yielding variety (HYV) crops has become possible. The yield of HYV crops is very sensitive to water and fertilizer inputs. In 1984/85, nearly 57% of gross cropped area of rice was under HYV; the corresponding figures for wheat were 83%, for jowar 33%, for bajra 49% and for maize 35%.

Table III.2.6 : Cropped and Net Irrigated Area

	Net Sown Area (million hectares)	Net Irrigated Area As a % of net sown area
1951/52	119.4	17.6
1955/56	129.2	17.6
1960/61	133.2	18.5
1965/66	136.2	19.3
1970/71	140.8	22.1
1975/76	142.2	24.3
1980/81*	140.3	27.6
1981/82*	142.0	28.1
1982/83*	141.8	28.2

* Provisional.

Source : The Fertilizer Association of India, Fertilizer Statistics, New Delhi, 1985-86.

Table III.2.7 : Gross Cropped and Gross Irrigated Area

	Gross Cropped Area (million hectares)	Gross Irrigated Area As a % of gross cropped area
1951/52	133.2	17.4
1955/56	147.3	17.4
1960/61	152.8	18.3
1965/66	155.3	19.9
1970/71	165.8	23.0
1975/76	171.0	25.4
1980/81*	173.1	28.8
1981/82*	177.0	29.1
1982/83*	172.6	30.1

* Provisional.

Source : The Fertilizer Association of India, op cit Ref. Table III.2.6.

Table III.2.8 : Net Irrigated Area by Sources of Irrigation ('000 hectares)

	Government Canals	Private Canals	Tanks	Tube Wells	Other Wells	Other Sources	Total
1950/51	7158	1137	3613	-- 5978	--	2967	20853
1960/61	9170	1200	4561	135	7155	2440	24661
1970/71	11972	866	4112	4461	7426	2266	31103
1978/79*	14270	838	3918	8178	8232	2525	37961
1982/83*	14875	495	3112	10684	8428	2375	39969

* Provisional.

Source : The Fertilizer Association of India, op cit Ref. Table III.2.6.

Table III.2.9 : Area Under Irrigation -- Cropwise ('000 hectares)

	1966/67	1970/71	1978/79	1982/83
All Crops	32754	38550	48090	52029
Rice	13298	14917	16847	16073
Wheat	6188	9829	14770	17066
Jowar	741	626	672	609
Bajra	380	514	424	661
Maize	800	925	901	2553
Others	11347	11739	14476	15067

Source : Fertilizer Association of India, op cit Ref. Table III.2.6.

Table III.2.10 : Area Under HYV Crops

	1967/68	1970/71	1975/76	1980/81	1984/85*
Rice					
- Area under HYV ('000 hectares)	1785	5588	12443	18234	23438
- As a % of gross cropped area	4.9	14.9	34.0	45.8	56.9
Wheat					
- Area under HYV ('000 hectares)	2942	6480	13458	16104	19582
- As a % of gross cropped area	19.7	35.5	65.8	72.9	82.9
Jowar					
- Area under HYV ('000 hectares)	603	802	1958	3500	5094
- As a % of gross cropped area	3.3	4.6	12.2	22.4	32.5
Bajra					
- Area under HYV ('000 hectares)	419	205	2897	3640	5248
- As a % of gross cropped area	3.3	1.6	25.0	31.3	49.3
Maize					
- Area under HYV ('000 hectares)	287	462	1132	1601	2056
- As a % of gross cropped area	5.1	7.9	18.8	26.7	35.4

* Anticipated Achievement.

Source : The Fertilizer Association of India, op cit Ref. Table III.2.6.

III.2c Irrigation Requirements

Irrigation water requirements depend on the type of crop, the type of soil, evaporation rate and so on. For cultivating non-rice crops in any particular agro-climatic zone in India, it has been observed that although the required frequency and depth of irrigation may vary significantly from one crop to another, total water requirement during the entire cropping season vary only within a fairly narrow range. Water requirements for rice cultivation however, are considerably higher -- about 120 cu.m/ha/day on clayey soils and about 180 cu.m/ha/day on loamy soils; this difference is due largely to the higher percolation losses in the latter type of soil.

It follows that total water requirements in a particular season will depend on whether the crop grown is rice or not. However, in actual practice, if rice is to be grown in one of the seasons, it is cultivated on a reduced field area, so that water requirements can be met. Therefore, it is reasonable to assume that in a given location, the choice of crop is not usually determined by the availability of water.

There are several factors, including the quality of seeds, the type of soil, climate and so forth, which affect the choice of crop and crop yield. However, it is observed that by and large, in all states in India, crop yields have risen with the availability of irrigation water.

As a result, crop irrigation has been promoted by the Central and State Governments. For resons mentioned in section III.2b, ground water irrigation has grown faster than surface irrigation. Despite this, only 68% of the potential ground water sources were exploited by 1984/85.

Among the various lift irrigation devices, the number of electric pumpsets has increased most rapidly. This is a direct outcome of the concerted drive undertaken by the REC to extend the grid to rural areas, so that electricity is available for agricultural purposes. The number of diesel pumpsets has increased most rapidly. This is a direct outcome of the concerted drive undertaken by the REC to extend the grid to rural areas, so that electricity is availabe for agricultural purposes. The number of diesel pumpsets has also increased, although relatively slowly. A certain (unknown) fraction of the diesel pumpsets are installed in rural areas which are already electrified. Other diesel pumpsets are installed for lift irrigation in areas where the utility's electric grid has still not been extended. While the population of mechanized pumping devices has increased, that of the animal powered water lifts has reduced. This is largely because the water draw-down through the use of electric and diesel pumpsets is so much, that non-mechanized pumps can not be used effectively.

Table III.2.11 : **Seasonal Water Requirements of Non Rice Crops***
(Cubic metre per hectare of sown area)

		Kharif (July-Oct.)	Rabi (Nov.-March)	Hot Weather (March-June)
a.	**Sub-Tropical Zone**			
a1	Hot, Arid	5000-6000	4000-5000	8000-9000
a2	Hot, Sub-Humid	4500-5500	4000-5000	6000-7000
b.	**Tropical Zone**			
b1	Hot, Sub-Humid, Humid	4500-5500	5000-6000	6500-7500
b2	Hot, Semi-Arid	6000-7000	6000-7000	9000-10000
b3	Hot, Arid	9000-10000	8000-9000	12000-14000

* Assuming 70% irrigation application efficiency, which is the ratio between water available to the crop, and that delivered by the pump.

a1 Includes Punjab, Haryana and Uttar Pradesh.
a2 Incudes Assam, Orissa and West Bengal.
b1 Includes Tamil Nadu, Kerala and parts of Karnataka and Andhra Pradesh.
b2 Includes Maharashtra and parts of Karnataka, Gujarat, Andhra Pradesh and Madhya Pradesh.
b3 Includes Rajasthan and parts of Gujarat and Madhya Pradesh.

Source : C. Dakshinamurti, Water Resources of India and their utilization in Agriculture, Water Technology Centre, Indian Agriculture Research Institute, New Delhi, 1973.

Table III.2.12 : Yield Differential due to Irrigation

	Yield (Quintals/hectare)		
	Irrigated Land	Unirrigated Land	% Yield
Andhra Pradesh	18.6	6.1	205
Bihar	10.9	8.0	36
Gujarat	10.9	6.9	174
Karnataka	23.3	6.3	270
Madhya Pradesh	12.9	7.1	82
Maharashtra	24.5	5.9	315
Punjab	23.6	10.6	123
Rajasthan	13.6	4.5	202
Tamil Nadu	23.1	8.1	185
Uttar Pradesh	20.4	8.6	137

* These are only macro-level data. Farm level variations are therefore missing. Besides, associated relevant information on the use of fertilizers, HYV seeds, etc. is not documented.

Source : S.D. Dhawan, Productivity Impact of Irrigation in India, Institute of Economic Growth, Sept. 1983.

Table III.2.13 : Ground Water Irrigation (Potential and Achievements)

	Ultimate Irrigation Potential* (million hectares)	Irrigation Potential exploited upto 1984-85* (%)
A. Major States		
Andhra Pradesh	4.2	54.8
Assam	1.7	23.5
Bihar	5.9	57.6
Gujarat	1.8	94.4
Haryana	1.6	87.5
Himachal Pradesh	0.3	33.3
Jammu & Kashmir	0.6	50.0
Karnataka	2.1	52.4
Kerala	1.1	36.4
Madhya Pradesh	4.2	47.6
Maharashtra	3.2	62.5
Orissa	2.3	47.8
Punjab	3.6	88.9
Rajasthan	2.4	83.3
Tamil Nadu	2.4	83.3
Uttar Pradesh	13.2	90.9
West Bengal	3.8	44.7
B. Other States	0.4	50.0
C. Union Territories	0.3	33.3
D. All-India	54.9	69.1

* The data relate to minor irrigation projects.

Source : Tata Services Limited, op cit. Ref. Table III.2.1.

Table III.2.14 : Population of Lift Irrigation Devices ('000)

	Electric Pumpsets	Diesel Pumpsets	Animal Powered Water Lifts
1950/51	21	66	3778
1960/61	200	230	4141
1968/69	1090	720	4675
1973/74	2430	1750	3682
1977/78	3300	2350	3505
1979/80	3950	2650	3326
1983/84	5309	3101	N.A.
1984/85	5708	N.A.	N.A.
1985/86	6152	N.A.	N.A.
1986/87	6479	N.A.	N.A.

Source : (i) T.G.K. Charlu and D.K. Dutt, Ground Water Development in India, Rural Electrification Corporation, New Delhi, 1982; and (ii) C.M.I.E.. Current Energy Scene in India, May 1987.

Table III.2.15 : Population of Electric Pumpsets ('000)

	1970/71(a)	1980/81	1986/87
A. Major States			
Andhra Pradesh	190	446	786
Assam	0.07	2	3
Bihar	66	160	208
Gujarat	70	231	334
Haryana	86	225	292
Karnataka	131	309	527
Kerala	19	91	151
Madhya Pradesh	58	317	544
Maharashtra	216	668	1085
Orissa	0.4	16	34
Punjab	91	283	481
Rajasthan	36	208	293
Tamil Nadu	481	919	1104
Uttar Pradesh	119	403	551
West Bengal	1	25	50
B. Other States(b)	0.5	3	3
C. Union Territories(c)	5	23	31
D. All-India	1570	4329	6479

a. As data is not available for the number of electric pumpsets, the number of consumers in the agriculture sector is given. The data for other years indicate that the number of pumpsets is marginally higher than the number of consumers.

b. The other states include Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland and Tripura.

c. The Union Territories include Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli, Delhi, Goa, Daman & Diu, Lakshadweep and Pondicherry.

Source : (i) CEA, Public Electricity, All India Statistics, General Reveiw; and (ii) CMIE, op cit Ref. Table III.2.14.

III.2d Land Preparation and Other Equipment

Although there is no coherent farm mechanization policy, the population of mechanized pumpsets has increased rapidly, and so have the number of tractors and other mechanical equipment.

Both diesel powered tractors and bullock power are used for land preparation. The number of draught animals has grown very marginally since the early 1960s, and the number of bullock powered plough shares increased gradually from about 40.6 million in 1961 to 47.5 million in 1977. However, the population of mechanized land preparation equipment (agricultural tractors, power tillers and crawler tractors) grew rapidly during this period. Similar trends may also be observed for equipment used for harvesting, threshing and so on.

Table III.2.16 : Population of Mechanical Devices ('000)

	1972	1977
a1 Agricultural Tractors (=< 35 hp)	97.2	187.2
a2 Agricultural Tractors (36-50 hp)	37.5	70.1
a3 Agricultural Tractos (> 50 hp)	9.8	17.9
b1 Power Tillers	17.2	16.0
c1 Crawler Tractors (=< 75 hp)	15.2	16.3
c2 Crawler Tractors (> 75 hp)	3.2	3.7
d1 Threshers	205.8	484.1
e1 Maize Shellers	15.7	18.5
f1 Harvestor Combine	7.7	4.3
g1 Power Operated Chaff Cutters	141.6	202.5
h1 Other Power Operated Equipment	33.5	44.7

Source : Ministry of Agriculture (G.O.I.), Indian Livestock Census 1977, New Delhi, 1984.

Table III.2.17 : Population of Non-Mechanical Devices ('000)

	1951	1956	1961	1966	1972	1977
Wooden Ploughs	51796	36142	38372	38923	39294	41031
Iron Ploughs	931	1376	2298	3523	5359	6516
Carts	9862	10968	12072	12697	12960	12670
Sugarcane Crushers Worked By Bullock	505	545	490	615	678	669

Source : Central Statistical Organization, Department of Statistics, Statistical Abstract, India, 1984.

Table III.2.18 : Population of Livestock ('000)

	1951	1956	1961	1965	1972	1977
a. Cattle (Total)	155295	158669	175557	176182	178341	180140
a1 Cattle used for work	60825	64313	70854	71159	72648	73287
- Male	58512	62840	68704	69176	70574	71240
- Female	2313	1833	2150	1983	2074	2047
b. Buffaloes (Total)	43400	44948	51210	52955	57486	62029
b1 Buffaloes used for work	6558	6373	7132	7358	7378	7662
- Male	6008	5953	6645	6972	7009	7323
- Female	550	420	487	386	369	339

Source : Central Statistics Organisation, op cit Ref. Table III.2.17.

III.2e Energy Consumption

Direct commercial energy inputs in agriculture are largely for two activities -- mechanized land preparation, and mechanized lift irrigation -- although commercial energy is also required for harvesting, threshing, drying and winnowing. As the use of commercial energy usually substitutes some form of human and/or animal energy, it is not correct to correlate direct commercial energy use with agricultural productivity. This observation may be validated further by noting that reliable irrigation facilities increase agricultural output in three ways : (i) by encouraging the use of high yielding varieties and inorganic fertilizers; (ii) by increasing the gross cropped area by making double/multiple cropping possible; and (iii) by bringing about a change in the cropping patterns.

Little information is available on the direct and indirect energy use. The singular exception is that of electricity sales, annual time series data for which are available at the state level. Data on average capacity ratings of electric pumpsets and their annual utilization patterns are also estimated and published. However, corresponding data for diesel pumpsets are not available.

The problem in estimating the utilization of diesel pumpsets is compounded further, because some (an unknown fraction) are used for standby purposes even by farmers who have an electric pumpset, while others are used by farmers in non-electrified rural areas. And even the total diesel consumption for ground-water irrigation and land preparation is also not easily determined from published data (Annual Petroleum and Petrochemical Statistics, GOI), because only a fraction of diesel sales for agricultural purposes are listed under a separate heading (Plantation/Food, including food processing), while an (unknown) fraction is clubbed together with transport. However, some norms for diesel consumption in, and annual hours of usage of diesel pumpsets, and various types of tractors, are estimated.

Indirect energy use through fertilizers is also not easy to estimate, because information on the use of only inorganic fertilizers is documented. The usage of organic manure may at best be estimated only on the basis of norms derived from isolated sample surveys.

Table III.2.19 : Use of Electric Pumpsets

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
a. No. of pumpsets energised ('000)	1629.4	2441.6	3029.2	3965.8	4973.3	5708.6
b. Connected Load (MW)	6224.8	9494.2	12053.0	15247.4	18712.3	21253.1
c. Electricity Cons. (GWh)	4470.23	6310.21	9620.63	13452.0	17816.84	20960.4
d. Average Capacity of pumpsets (hp)	5.03	5.12	5.24	5.06	4.95	4.99
e. Electricity Cons. per pumpset (kWh)	2743	2584	3176	3392	3640	3672
f. Electricity Cons. per unit of connected load (kWh/kW)	718	665	798	882	952	986

Source : CEA, Public Electricity Supply (All India Statistics) : General Review, New Delhi, various issues.

Table III.2.20 : Normative Data for Diesel Pumpsets and Land Preparation Equipment

a. Diesel Pumpset	
a1 Average capacity	7 hp
a2 Diesel cons. rate	0.2 kg of HSD per BHP - hour
a3 Annual usage	1000 hours
b. Land Preparation Equipment	
b1 Agricultural tractors	
- average rating	30 hp
- diesel cons. rate	2.7 litres/hour
- annual usage	1000 hours
b2 Power tillers	
- average rating	8.5 hp
- diesel cons. rate	1.25 litres/hours
- annual usage	1000 hours
b3 Crawler tractors	
- average rating	65 hp
- diesel cons. rate	6.5 litres/hour
- annual usage	1000 hours

Source : Advisory Board on Energy (G.O.I.), Towards a Perspective on Energy Demand and Supply in India in 2004/05, May 1985.

Table III.2.21 : Total Diesel and Electricity Consumption

	1970/71	1973/74	1976/77	1979/80	1982/83	1983/84	1984/85	1985/86
Electricity Cons. (GWh)	4470.23	6310.21	9620.63	13452.0	17816.84	18230	21400	23532.45
Diesel Cons.* ('000 tonnes)	N.A.	N.A.	N.A.	N.A.	141	145	157	177**

* Accounts for consumption of HSD and LDO in the Plantation/Food (including processing) sector.

** Provisional

Source : (i) CEA, Public Electricity Supply, (All India Statistics), General Review, various issues; (ii) CMIE, Current Energy Scene in India, May 1987; and (iii) Ministry of Petroleum and Natural Gas, Indian Petroleum & Natural Gas Statistics, various issues.

Table III.2.22 : All India Consumption of NPK Fertilizers ('000 tonnes)

	Nitrogenous Fertilizers	Phosphatic Fertilizers	Potassic Fertilizers	Total
1951/52	58.7	6.9	-	65.6
1955/56	107.5	13.0	10.3	130.8
1960/61	211.7	53.1	29.0	293.8
1965/66	574.8	132.5	77.3	784.6
1970/71	1479.3	541.0	236.3	2256.6
1975/76	2148.6	466.8	278.3	2893.7
1980/81	3678.1	1213.6	623.9	5515.6
1981/82	4068.7	1322.9	676.2	6067.8
1982/83	4242.5	1432.7	726.3	6401.4
1983/84	5204.4	1730.3	775.4	7710.1
1984/85	5486.1	1886.4	838.5	8211.0
1985/86*	5811.4	2063.3	847.3	8722.0

* Provisional

Source: The Fertilizer Association of India, op cit Ref. Table III.2.6.

III.3 INDUSTRY

III.3a Introduction

Industry is a major energy consuming sector in India. However, the available data base is woefully inadequate and out-of-date. The most recent period for which data on industrial output, and energy and other inputs are available, is 1978/79; these data are upto a 4-digit level of classification as per the SIC system. Summary results (for industries classified upto a 3-digit level as per the SIC system) are also available for 1982/83. These summary results however, present all energy consumption data only in monetary terms. As energy prices vary from state to state, and at least for coal, from one part of a state to another, it becomes difficult to use such data meaningfully for analytical work.

Where time series data are available in physical units, the classification of industries for which coal consumption data are available, is not consistent with that for petroleum products or/and electric power consumption data. This makes it difficult even to estimate energy consumption of various industrial categories, except at very aggregate levels of classification. Furthermore, consumption of fuelwood and charcoal -- which are used particularly in the unregistered manufacturing sector -- is not documented.

A simple analysis shows that the following manufacturing industries spend a very high portion of their value added on energy purchases : (i) non-metallic mineral products (SIC code : 32); (ii) basic metals and alloys (SIC : 33); (iii) chemicals and chemical products (SIC : 31); (iv) paper and paper products (SIC code : 28); and (v) cotton textiles (SIC Code : 23). These industrial categories are also likely to be more energy intensive than other manufacturing industries. Detailed data on some particular energy intensive manufacturing industries are presented in subsequent sections.

Table III.3.1(a) : Value Added from Manufacturing -- Registered Sector (Rs. million, 1970/71 prices)

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
a. Food Products	2681.5	2047.9	2891.5	3346.6	4545.2	4232.6
b. Beverages, tobacco and tobacco Products	991.1	798.5	1422.7	1222.7	1201.8	1158.4
c. Textiles	5973.0	7796.1	7703.0	10228.7	9258.2	10303.4
d. Wood & Wood Products	309.4	270.8	266.2	298.2	246.8	275.5
e. Paper & Paper Products	1495.9	1524.7	1608.3	1756.0	1715.4	1941.7
f. Leather, Leather & Fur Products	22.0	151.2	198.4	208.4	245.1	288.1
g. Rubber, Plastic, Petroleum and Coal Products	1289.0	1157.3	1738.1	1746.5	2380.3	2698.9
h. Chemicals & Chemical Products (excluding coal & petroleum)	3670.7	4817.2	5212.6	6979.4	7758.9	8933.0
i. Non-metallic mineral Products	1139.9	1166.6	1286.3	1387.5	2000.2	2184.8
j. Basic Metal & Alloy Industries	2845.1	3079.2	4188.2	4037.6	4972.4	5329.6
k. Metal Products and Parts (excluding Machinery, Transport Equipment)	945.4	1087.2	1120.8	1369.7	1305.9	1307.2
l. Machinery, Machine tools, and parts (excluding Electrical Machinery)	1938.6	2433.9	3276.8	3470.8	4120.7	4954.5
m. Electrical Machinery, Appliances and Apparatus.	1821.3	2707.2	2936.5	3517.6	5346.6	5860.8
n. Transport Equipment & Parts	2439.6	2577.3	2839.9	3206.7	4302.4	5900.0
p. Miscellaneous Manufacturing Industries	1865.2	1562.1	1531.6	1610.4	2644.0	3459.1
q. Repair Services	-	639.7	976.9	800.6	909.9	1115.0
r. Net Value Added	28740.0	32769.3	38054.4	43934.5	50807.4	57104.1
s. Consumption of Fixed Capital	5315.4	5279.1	5290.5	6473.7	7328.5	8227.7
t. Gross Value Added	34055.4	38048.4	43344.9	50408.2	58135.9	65331.8

Source : Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, various issues.

Table III.3.1(b) : **Value Added from Manufacturing Sector -- Unregistered Sector (Rs. million, 1970/71 prices)**

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
a. Food Products	1841.1	1835.6	1946.7	1977.0	2325.2	2641.8
b. Beverages, tobacco and tobacco Products	1040.9	982.6	1513.5	1516.9	1834.9	1617.9
c. Textiles	4461.1	5366.7	6029.3	7795.5	8930.1	9708.1
d. Wood & Wood Products	2204.3	2288.1	2695.1	2302.7	1969.1	1868.7
e. Paper & Paper Products	510.6	556.6	614.7	867.9	877.0	821.3
f. Leather, Leather & Fur Products	690.7	697.6	748.6	780.9	869.7	914.2
g. Rubber, Plastic, Petroleum and Coal Products	182.0	247.0	275.6	315.6	372.2	422.2
h. Chemicals & Chemical Products (excluding coal & petroleum)	583.7	730.8	889.8	1012.3	1197.5	1378.1
i. Non-metallic mineral Products	934.2	1086.5	1503.7	1666.5	1912.5	2090.9
j. Basic Metal & Alloy Industries	46.2	43.7	70.4	66.5	78.0	83.7
k. Metal Products and Parts (excluding Machinery, Transport Equipment)	1177.2	1379.6	1459.1	1749.5	1750.6	1753.2
l. Machinery, Machine tools, and parts (excluding Electrical Machinery)	637.5	866.9	843.3	1015.9	1177.2	1415.5
m. Electrical Machinery, Appliances and Apparatus.	362.7	450.1	478.2	576.4	626.8	686.8
n. Transport Equipment & Parts	534.6	608.3	727.7	743.2	836.6	1147.2
p. Miscellaneous Manufacturing Industries	1325.8	1479.6	1556.8	2274.6	1676.9	1699.5
q. Repair Services	1060.3	1321.1	1343.4	1542.8	1736.8	2128.8
r. Net Value Added	17453.6	19746.0	22354.0	25792.0	27540.3	29625.1
s. Consumption of Fixed Capital	720.3	814.2	981.5	1124.6	1215.6	1307.3
t. Gross Value Added	18173.9	20560.2	23335.5	26916.6	28755.9	30932.4

Source : Central Statistical Organization, op cit Ref. Table III.3.1 (a).

Table III.3.2 : Production of Selected Industries

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85	1985/86
a. Metallurgical Industries							
Pig Iron(million t)	6.99	7.0	10.02	8.58	9.58	9.24	10.01
Finished Steel (million t)	4.64	4.47	6.80	6.90	8.05	7.78	9.49
Aluminium ('000 t)	168.8	147.90	208.70	191.90	211.50	276.50	251.50
Blister Copper ('000 t)	9.3	12.7	23.7	22.5	35.8	41.0	33.6
b. Chemical & Allied Industries							
Nitrogenous fert. ('000 t)	830	1060	1900	2226	3424	3917	4328
Phosphatic fert. ('000 t)	229	319	474	757	980	1264	1417
Soda Ash ('000 t)	449	480	571	556	635	817	918
Caustic Soda('000 t)	371	419	497	550	577	684	726
Paper & Paper Board ('000 t)	755	776	899	1058	1205	1376	1517
Cement (million t)	14.3	14.7	18.8	17.6	23.3	29.5	32.0
c. Textile Industries							
Jute Textiles (' 000 t)	1060	1074	1186	1137	1338	1370	1351
Cotton cloth (million m)	7602		7682	7533	7953	9040	9178
Mixed/blended cloth (million m)	170	7956	716	1529	1293	1278	1337
Artificial fibres (million m)	951	N.A.	902	1366	1368	1696	1983
d. Food Industries							
Sugar ('000 t)	3740	3948	4943	3859	8232	6143	7003
Vanaspati ('000t)	558	449	541	618	886	936	868
Salt ('000 t)	5568	N.A.	4531	6484	7823	8304	8500
e. Engineering Industries							
Machine tools (million Rs.)	430	673	1163	1652	2699	3028	2914
Automobiles ('000)	87.9	99.8	91.3	104.6	151.4	196.0	209.3
Power transformers (million KVA)	8.09	12.42	15.09	18.63	18.6	25.39	27.25
Electric motors (million HP)	2.72	3.24	3.68	3.74	4.81	4.94	5.25

Source : G.O.I., Economic Survey, Various issues.

Table III.3.3 : Energy Consumption in Industry

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85	1985/86(a)
Electricity purchased from utilities (GWh)	29579.1	32481.4	41605.6	45955.5	53063.8	N.A.	N.A.
Self generated electricity (GWh)	5347.2	6067.5	7240.3	8157.0	9989.0	N.A.	N.A.
Total Electricity Cons. (GWh)	34926.3	38548.9	48845.9	54112.5	63052.8	N.A.	N.A.
Fuel Oils Cons.(b) ('000 t)	N.A.	N.A.	3641.0(c)	3895.0(c,e)	4304.0(d)	4427.0(d)	4410.0(d)
Naphtha Cons ('000t)	N.A.	N.A.	2183.0	2413.0	2958.0	3125.0	3128.0
HSD Cons ('000t)	N.A.	N.A.	610.0(f)	1097.0(g)	876.0	1857.0(f)	2001.0(f)
LDO Cons. ('000t)	N.A.	N.A.	877.0(f)	1103.0(h)	302.0	1103.0(f)	1017.0(f)
LPG Cons. ('000t)	N.A.	N.A.	52.0	56.0	70.0(i)	99.0(j)	115.4(j)
Coal Cons(k) (million t)	N.A.	42.5	55.8	60.8	67.3	N.A.	N.A.

a. Provisional
b. Furnace Oil, LSHS and HHS. Excludes fuel oils used for power generation
c. Includes consumption of DGS&D
d. Excludes consumption of DGS&D
e. In addition about 576000 tonnes of LSHS/HHS were used in 1979-80, of which, 243000 tonnes was used in the Iron & Steel Industry alone.
f. Includes HSD/LDO used for power generation, plantation/food processing, agriculture retail trade and DGS&D sectors
g. Includes HSD used for power generation and plantation/food processing
h. Includes LDO used for plantation/food processing but excludes power generation
i. Includes L.P.G. used in commercial sector only
j. Includes L.P.G. used in commercial sector, too.
k. Includes coal used for making hard coke, but which is not used in the steel industry

Source : (i) CEA, Public Electricity Supply (All India Statistics) : General Review, New Delhi, various issues; (ii) Department of Petroleum, Indian Petroleum & Petrochemical Statistics, New Delhi, various issues; and (iii) Coal Controllers Organization, All India Annual Coal Statistics, 1983-84, G.O.I., Calcutta.

Table III.3.4 : Manufacturing Industry's Expenditure on Fuel in 1982/83

SIC Code	Manf. Industry	Fuel Cons. (Rs. million)	Val Of Op (Rs. million)	Net VA (Rs. million)	Fuel/Op (%)	Fuel/VA (%)
32.	Non-metallic Minerals	5385.4	27304.8	7394.2	19.7	72.8
33.	Basic Metals	12335.3	106694.0	18037.8	11.6	68.4
28.	Paper	2277.9	21835.0	5173.5	10.4	44.0
31.	Chemicals	10262.8	109883.0	20456.7	9.3	50.2
23.	Cotton textiles	4787.6	59559.2	11660.3	8.0	41.0
25.	Jute, Hemp	556.1	7650.5	2241.8	7.3	24.8
27.	Wood etc.	147.8	3850.8	782.7	3.8	18.9
21.	Food	1551.7	45912.4	4031.4	3.4	38.5
34.	Metal pdts	577.3	17584.8	3812.4	3.3	15.1
37.	Transport Equipment	1549.4	47642.2	13091.4	3.3	11.8
22.	Beverages Tobacco	378.9	14170.5	2619.3	2.7	14.5
97.	Repair Services	262.8	10161.8	2374.0	2.6	11.1
35.	Machinery	1240.3	48099.4	11906.5	2.6	10.4
20.	Food	1778.2	72888.5	7853.0	2.4	22.6
24.	Wool, Silk Textiles	727.7	29831.6	5366.5	2.4	13.6
36.	Electrical Machinery	1000.2	47406.5	11972.9	2.1	8.4
38.	Other Industry	109.9	5791.8	1652.7	1.9	6.6
30.	Rubber, Plastic	1855.3	101239.9	95230	1.8	19.5
29.	Leather, Fur	109.9	6258.1	847.0	1.8	13.0
26.	Textile products	153.9	10886.5	1646.6	1.4	9.3

Op : Output.
VA : Value Added.

Source : Central Statistical Organisation, Annual Survey of Industries, Summary Results For Factory Sector, August 1986, GOI, New Delhi.

III.3b Fertilizer Industry

In 1984/85, the fertilizer industry accounted for nearly 75% of all naphtha consumption in the country, along with about 39% of natural gas, 12% of furnace oil and 26% of LSHS/HHS. 'Relatively small quantities of HSD/LDO and electricity were also consumed. In terms of calorific content, naphtha has the largest share in commercial energy consumption.

In India, the production of nitrogenous fertilizers (particularly urea) is more than that of other types of fertilizer. Nitrogenous fertilizers are also relatively more energy intensive. However, the energy consumption intensity of urea manufacture has somewhat reduced during the past two decades or so. It may be related to the type of feedstock, technology employed, unit capacity and capacity utilization. These issues are discussed briefly below.

As one goes from heavier to lighter feedstock, the energy intensity reduces. This implies that (with other things held equal) the intensity reduces as the feedstock is changed from coal to fuel oil, from fuel oil to naphtha, and from naphtha to natural gas. However, a survey conducted by TERI shows that the intensity of using naphtha is marginally higher than that of using fuel oil. This may be due to a relatively lower capacity utilization of the naphtha-based plants surveyed. A continuous operation at high capacity leads to lower energy intensities, because plants functioning at lower loads also experience the same level of heat losses, purge losses and leaks, as those operating at full load. With an increase in plant load, it is clear that these "constant" losses have less impact on the overall energy consumption intensity.

Recent advances in process technologies and catalysts have also resulted in better intensity norms. For example, consumption of naphtha (feed and fuel) per tonne of ammonia guaranteed by various technology suppliers has reduced from 0.9 - 1.0 tonne during the 1970s, to 0.8 - 0.85 tonne in the 1980s. Similarly, the consumption of ammonia per tonne of urea has also reduced from 0.6 tonne to 0.58 tonne. Along side, the stream sizes of urea making units have also grown, thus reaping the benefits of economies of scale.

All data in Tables III.3.5 through Tables III.3.9 are quoted from : H. Harish and V.S. Kothari, "Energy Use in Fertilizer Industry", TERI Discussion Paper DP/01/87, New Delhi, 1987.

Table III.3.5 : Energy Consumption in the Fertilizer Industry

Energy Form	1982/83	1983/84	1984/85
Naphtha ('000 tonnes)	2282	2134	2313
Furnace Oil('000 tonnes)	670	574	390
LSHS/HHS ('000 tonnes)	883	913	687
Natural Gas (million cubic metres)	1155	1280	1603(p)
HSD/LDO ('000 tonnes)	21	28	19
Coal (MMT)	4.15	4.21	3.99(p)
Electricity* (GWh)	4120	4464	N.A.

* The total electrical energy consumed by the fertilizer industry consists of electrical energy purchased and generated internally. The consumption of coal, fuel oil etc. for internal generation of electricity is included in the consumption figures for the respective energy forms. Electricity consumption figures in the table are for purchased electrical energy only.

p : Provisional.

Table III.3.6 : Production of Fertilizers in 1985/86

Fertilizer	Capacity ('000 t)	Production ('000 t)	No. of Units
Urea	12101	7465.3	34
Single Superphosphate	3811.1	2136.1	69
Diammonium Phosphate	1283	894.2(a)	9
Ammonium Phosphate Sulphate (a)	200	454(b)	3

a. For 1984/85.

b. Production greater than capacity, as also produced by units licensed to manufacture other complex fertilizers.

Table III.3.7 : Specific Energy Consumption for Urea Production* from Different Feedstocks for Ammonia

Ammonia Feedstock	Average Capacity Utilization (%)	Energy Consumption (GCal/tonne urea)
Coal	26	29.01
Fuel Oil	73	12.7
Naphtha	65	13.3
Gas	90	8.95

* Includes energy consumption in ammonia production.

Table III.3.8: Nitrogen(N) Capacity in 1986, According to Sources of Feedstock for Ammonia

Feedstock	Share of Capacity (%)
Naphtha	37.3
Natural Gas	30.9
Fuel Oil	17.4
Coal	6.7
Coke/Coke oven gas	1.0
Electrical Supply	5.5
Total	100.0

Table III.3.9 : Growth of Stream Size in Ammonia and Urea Units in India

Year	Ammonia (tonnes/day)	Urea (tonnes/day)
1969	500	800
1974	900	1500
1982	1350	1800
1983	2x1350	3x1500

III.3c Aluminium Industry

At present, six smelters are operated by four companies : (i) The Bharat Aluminium Company Ltd. (BALCO) at Korba in Madhya Pradesh; (ii) The Indian Aluminium Company (INDAL) at Belgaum in Karnataka, Hirakud in Orissa, and Alwaye in Kerala; (iii) The Hindustan Aluminium Company Ltd (HINDALCO) at Renukoot in Uttar Pradesh; and (iv) The Madras Aluminium Company Ltd. (MALCO) at Mettur in Tamil Nadu. The smelters at Korba, Belgaum, Renukoot and Mettur are integrated plants, i.e., all process steps for converting bauxite to the finished product take place at the same location. For the INDAL smelters at Alwaye and Hirakud, alumina is the input material -- this alumina is produced at INDAL's alumina plant at Muri in Bihar.

The installed capacity and production of the aluminium industry has grown steadily over the last ten years or so. The two major energy consuming steps are : (i) bauxite ore conversion to alumina; and (ii) production of aluminium from alumina.

In the production of alumina, fuel oil is used for firing calcining kilns. Besides calcination, some units also use fuel oil to generate the steam required for digestion and evaporation. Coal is used only for steam generation while electricity is used largely for bauxite grinding. Using about 110 litres of fuel oil per tonne of alumina, the calcination process at the INDAL's Muri and Belgaum plants is least energy intensive. This is due largely to better operation and improved heat recovery. The fuel oil consumption in calciners of other units is around 135 litres/tonne.

Electricity is the major source of energy utilized in smelters for aluminium production. Petroleum coke, coal tar pitch and coke, which may also be used as an energy fuel, are used for anode making. Besides, fossil fuels are also required for steam generation. The electricity intensity at BALCO and MALCO is relatively high, mainly because of unavailability of adequate and steady power supplies -- which lead to frequent shut-downs and low capacity utilization.

All data in Tables III.3.10 through III.3.13 are obtained from : N.Thangaraju and V.S. Kothari, "Energy Use in Aluminium Industry", TERI Discussion Paper DP/02/86, New Delhi, 1986.

Table III.3.10 : Installed Capacity, Production and Capacity Utilization of the Aluminium Industry

	Installed Capacity ('000 tonnes)	Production ('000 tonnes)	Capacity Utilization (%)
1970/71	156	167	107.1
1975/76	246	187	76.0
1979/80	321	192	59.8
1980/81	321	199	62.0
1981/82	321	207	64.5
1982/83	321	208	64.8
1983/84	362	220	61.0
1984/85	362	273	75.4

Table III.3.11 : Energy Requirements in Alumina Production (per tonne of alumina)(a)

Energy Form and End Use	BALCO	HINDALCO	INDAL (Belgaum)	INDAL (Muri)	MALCO
Electricity (KWh)	537	393	232	337	327
Grinding Hydration(b)	N.A.	354	199	303	301
Calcination	N.A.	39	33	34	26
Fuel Oil (Litres)	177	136	297	110	487
Calcination	136	136	112	110	131
Steam Generation	41(c)	-(d)	185(c)	-	356(c)
Coal (kg)					
Steam Generation	466(c)	970(c)	-	1165	-

a. The figures are based on data for the periods mentioned below : (i) BALCO - 1977/78 to 1983/84; (ii) HINDALCO - 1977 to 1985; (iii) INDAL - 1979 to 1983; and (iv) MALCO - 1980 to 1982.

b. Processes upto precipitation of alumina in Bayer process.

c. Includes fuel used to generate steam consumed in anode paste preparation.

d. Not Applicable.

Table III.3.12 : Energy Requirements in Aluminium Production (per tonne of aluminium)(a)

Plant/ Energy Form	BALCO	HINDALCO	INDAL (Alwaye)	INDAL (Belgaum)	INDAL (Hirakud)	MALCO
Smelter						
Electricity (kWh)	18107	16565	18016(b) 167733(c)	17060	16920	19620
Anode Plant						
Electricity (kWh)	N.A.	112	N.A.	N.A.	N.A.	N.A.
Coal for Steam (Kg)	N.A.	68	N.A.	-(d)	N.A.	-
Fuel Oil for baking (Litres)	-	110	N.A.	-	N.A.	-

a. The figures are based on data for the following periods: BALCO 1977-78 to 1983-84; HINDALCO 1977-83, INDAL 1979-83; MALCO 1980-82.
b. For 23 KA pot line.
c. For 49 KA pot line.
d. Not applicable

Table III.3.13 : Energy Use in Alumina Plants - An International Comparison (per tonne of alumina)

	India	Australia	Guinea	Jamaica	Surinam
Thermal (GCal)					
Steam	3492.1	3601.4	3235.6	3965.6	848.9
Calcination	1242.5	1221.2	1221.2	1221.2	1221.2
Electrical (kWh)					
Electricity	362	240	240	240	240

III.3d Textile Industry

The textile industry comprises : (i) cotton textiles; (ii) wool, silk and synthetic fibre textiles; and (iii) jute textiles. Cotton textile manufacture, which is the predominant sub-sector in the textile industry, consists of : (i) the organized sector; and (ii) the decentralized sector, which has both power-loom and hand-loom mills. The organized cotton textile sub-sector, which has about 700 mills, is facing financial problems, not only because it is labour intensive, but also because it has old and antiquated machinery and a poor maintenance record.

The textile industry consumes around 9% of the total commercial energy consumed in the country. About 80-85% of its energy needs are thermal, and the rest electrical. Coal and furnace oil meet the process heat requirements. All textile mills, except for those around Bombay, use coal in boilers. An estimated 80-90% of the electricity used is for motive power for driving pumps, motors, drives etc. The energy bill of most textile mills accounts for 10-15% of the total input costs.

There is a substantial scope for energy conservation in the textile industry. Low efficiency boilers, with efficiency levels of 50-60% are in operation in a large number of mills. These boilers may easily be retrofitted with suitable heat recovery equipment. Besides, cogeneration may also be possible, because several mills use 60% of the required steam below 60 psig, while their boilers generate steam at 150 psig or more.

Table III.3.14 : Textile Industry -- Index Number of Capacity, Production and Capacity Utilization

Year	Capacity	Production	Capacity Utilization (%)
1970	100.0	100.0	75
1975	105.5	108.1	77
1976	110.7	112.1	76
1977	115.0	111.0	72
1978	113.5	117.8	78
1980	120.0	123.9	77
1981	119.3	127.4	80
1982	128.9	107.0	62
1983	129.2	116.5	68
1984	129.7	106.7	62
1985	132.0	109.8	62

Source : Centre for Monitoring Indian Economy, Production and Capacity Utilization in 600 Industries, 1970-85.

Table III.3.15 : Existing Structure of the Textile Industry

	Handloom (%)	Powerloom (%)	Organized Sector(%)	Total cloth output (million metres)
1979/80	29	30	41	10454
1986/87	26	48	26	12800

Source : The Hindu, June 4, 1987.

Table III.3.16 : Energy Consumption in the Textile Industry

	Electricity (GWh)			Coal(MMT)			Fuel Oils* ('000 t)
	Textile	Jute	Total	Jute	Cotton	Total	
1970/71	3950.5	659.8	4610.3	-	-	-	-
1973/74	4055.6	651.5	4707.1	0.14	1.78	1.92	-
1976/77	5123.9	880.4	5804.3	0.18	2.41	2.58	570
1979/80	5743.2	700.2	6443.4	0.14	1.99	2.13	430
1982/83	5909.4	761.3	6870.7	0.17	2.94	3.11	334
1984/85	-	-	-	-	-	-	430

* Includes Furnace Oil, LSHS and HHS.

Source : CEA, Dept. of Petroleum, Coal Controller's Organization, op cit Ref. Table III.3.3.

Table III.3.17 : Energy Use Intensity of the Textile Industry

	Electricity (kWh)	Coal (kg)
Cotton (per metre)	0.9	0.75
Polyster (per metre)	-	1.25
Jute (per tonne)	545	23.2

Source : Inter-Ministerial Working Group, "Utilization and Conservation of Energy - Sectoral Reports", New Delhi, 1983.

III.3.e Cement Industry

During the Sixth FYP period, the Indian cement industry recorded significant growth. Production grew at 10% per annum, and installed capacity at 13%. By the end of the Seventh FYP period, the installed capacity is anticipated to rise to about 62 MMT.

At present, the Indian cement industry produces thirteen varieties of cement, of which three comprise more than 95% of the total production; (i) ordinary portland cement; (ii) portland pozzolona cement; and (iii) portland slag cement.

The technology for cement manufacture has changed substantially in India, during the past three to four decades. While plants based on the wet process were established in the 1950s and early 1960s, those with dry process have been set-up thereafter. Dry process cement plants, which are comparatively less energy intensive, now account for over 60% of the installed capacity. The precalcinator technology has also now been introduced in India.

Electric power and coal are the major energy forms used in the cement industry, although some plants use furnace oil and lignite also. The cement industry accounts for over 10% of the industrial sector's coal consumption, and over 6% of the sector's electricity consmption. Although the overall energy intensity of the cement industry has declined during the past decade or more (due largely to an increasing share of production from dry process based cement plants), the energy consumption norms in India are significantly higher than what has been achieved internationally.

A further reduction in energy intensity is likely to be possible from : (i) basing all future plants on the dry process; and (ii) better house-keeping at the plant level.

All data in Table III.3.18 through III.3.20 are obtained from TERI data files.

Table III.3.18: Energy Consumption in the Cement Industry

	1973/74	1976/77	1979/80	1982/83	1985/86
Electricity (GWh)	1283.8	2340.1	2035.7	2516.9	N.A.
Coal ('000 tonnes)	3650	4970	3870	6100	7900
Fuel Oils ('000 tonnes)	N.A.	42	154	41	54

Table III.3.19: Energy Consumption Norms per Tonne of OPC Cement

Process	Thermal GCal	Thermal Coal (Kg)	Electrical (kWh)	Total (GCal)
Wet	1.59	330	118	1.69
Dry	0.98	214	135	1.098
Semi-Dry	1.11	248	135	1.226

Note : 1 KWh = 860 kCal

Table III.3.20 : Energy Consumption in 1983/84 Comparison With International Consumption

Process	Energy Type	Indian Scenario	World Scenario
Wet	Electricity(kWh/tonne)	114	87
	Thermal (GCal/tonne)	1.657	1.243
Dry	Electricity (kWh/tonne)	155	111
	Thermal (GCal/tonne)	0.977	0.769

III.4 TRANSPORT SECTOR

III.4a Introduction

The share contribution of the transport sector to total GDP was just over 16% in 1970/71; and increased to nearly 20% by 1985/86. The gross value added by the transport sector grew by nearly 5.4% per annum during the sixteen year period. That transport services have grown, reflects not only a growth in economic activity, but also an increase in leisure related travel.

The transport sector is a major energy consuming -- and oil consuming -- sector. It is therefore important to analyze the implications on energy consumption, of any transport planning/policy-formulation exercise.

Since the mid 1960s, the transport sector has accounted for 12-16% of total public sector investments; while it accounted for as much as 22-23% of public investments during the First, Second and Third Five Year Plan periods. Of the total public sector investments on transport, over 75% has always been reserved for the rail and road sub-sectors. Consequently, these two modes are the major forms of transport in the country.

The railways' share of both freight and passenger traffic has decreased since the early 1960s. This may be due to the relative decline in the railways' share of public sector expenditures, particularly from the Third FYP period to the Sixth FYP Period -- when the share of traffic handled by road increased rather rapidly. The role of road transport grew also because, in addition to public investments, there is a considerable investment in the private sector as well -- as evident from the private ownerwhip of cars/taxis, two-wheelers, trucks and other vehicles. However, it appears that the Government is making an effort to reverse this trend during the Seventh FYP period, by allocating for the railways, nearly 55% of the public sector outlay for the entire transport sector.

Table III.4.1: Plan Allocations For The Transport Sector (%)

Sub-Sector	1st Plan	2nd Plan	3rd Plan	Annual Plans	4th Plan	5th Plan	6th Plan	7th Plan
Railways	50.0	65.7	66.9	49.3	37.0	40.6	42.2	54.6
Roads & Road Transport	33.9	22.0	23.5	5.3	39.3	33.5	38.4	31.8
Shipping *	10.8	7.8	6.9	8.4	16.3	19.1	11.7	9.2
Inland Water Transport	-	-	0.2	0.6	0.4	0.6	0.6	1.0
Civil Air Transport	5.3	4.5	2.5	6.4	7.0	6.2	7.1	3.4

* Includes all Ports and Lighthouses.

Source: (i) Planning Commission (GOI), Report of the National Transport Policy Committee, New Delhi, May 1980; (ii) Planning Commission (GOI), Seventh Five Year Plan, 1985-90 Vol. II, New Delhi, October 1985.

Table III.4.2: Value Added In Transport Sector (Rs. million, 1970/71 Prices)

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
Total	13633.7	15155.3	20423.2	23799.1	28454.2	32968.6
Railways	5220.0	5015.3	7000.4	7168.8	7018.8	7256.3
Road	6293.2	7494.2	8728.4	11185.6	15004.2	18539.2
Water	1191.7	1457.5	2021.1	1857.0	1992.0	2085.4
Air	480.8	741.3	974.6	1485.5	1982.1	2306.3
Service incidental to transport	124.6	136.1	1019.2	1305.2	1663.4	1889.1
Storage	323.4	310.9	679.5	797.0	793.7	892.3

Source : Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, Various issues.

Table III.4.3: Trends In Relative Rail And Road Traffic

	1960	1970	1980	1981	1982	1983	1984	1985
a. Freight Traffic								
a1. Total (Billion t-km)	108.3	190.8	295.0	319.7	357.2	371.3	386.5	416.1
- Rail (%)	75.7	67.3	52.9	49.6	48.8	45.2	43.2	41.5
- Road (%)	24.3	32.7	47.1	50.4	51.2	54.8	56.8	58.5
b. Passenger Traffic								
b1. Total (Billion p-km)	164.3	345.2	726.6	869.9	945.2	969.3	1059.7	1145.3
- Rail (%)	44.9	32.3	27.4	24.0	23.4	23.4	21.1	19.8
- Road (%)	55.1	67.7	72.6	76.0	76.6	76.6	78.9	80.2

Source: Engineering Consultants Pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the Year 2000 A.D.", Prepared for the Department of Surface Transport (Road Wing), GOI, January 1987.

III.4b Railways

The Indian Railway system is over a hundred years old, with a route network of nearly 62,000 km and a running track of over 106,000 km. It developed as a multi-gauge system with tracks in the broad gauge (1.76 metres wide), the metre gauge (1.0 metre wide) and the narrow gauge (0.762 metre and 0.610 metre wide). As a result, the railways have suffered from problems of change/break of gauge for long haul movements.

Since the early 1960s, a significant share of investments have been for upgrading metre and narrow gauge tracks to broad gauge tracks, as well as for laying additional broad gauge tracks on existing routes. The expansion of broad gauge tracks has been promoted because it enables a relatively higher tonnage of traffic throughput.

The Government initiated the track electrification programme in the 1950s. However, recognizing that electrification is capital intensive and economical only if traffic density exceeds a certain threshold level, dieselization of railways was considered a viable alternative in the interim period. Consequently, diesel traction increased much faster than electric traction, as traffic carried by the railways did not expand as anticipated (thus

making electrification viable only on rather small portions of the track network). Furthermore, a concerted effort to phase out steam engines also lead to an increase in diesel traction.

Total revenue and non-revenue earning freight traffic increased at a rate of 3.2% per annum from 1970/71 to 1985/86. Freight traffic in fact stagnated during the mid and late 1970s, and picked up only after 1979/80, when it increased at a rate of 4.7% per annum until 1985/86. Although this slow growth in freight throughput of the railways during 1976/77 to 1979/80 may have been due to a stagnation in economic activity (such as coal production, iron ore exports etc.), it was also due largely to infrastructural bottlenecks.

In fact, for revenue earning freight traffic (which accounts for over 90% of total freight traffic), there has been a general trend of an increase in the average lead distance. This perhaps indicates that a gradually increasing share of short haul freight traffic has been handled by other modes of transport. The same is true for both suburban and non-suburban passenger traffic as well. Average lead distance in suburban passenger traffic has increased with the extension of the railway network to more distant suburbs of Bombay, Calcutta and Madras; while the increase for non-suburban traffic occurred largely because public sector road transport services began to cater to short distance inter-city/inter-town passenger traffic.

Energy consumption data disaggregated for freight and passenger traffic are not available, except for electricity consumption data for suburban passenger traffic. Energy consumption per gross tonne-km equivalents of freight and passenger traffic may be estimated at an aggregate level. Available data indicate that there has been a steady decline in the overall energy consumption intensity of the rail transport system since 1970/71, but only due to a major switch in locomotive power, from energy intensive coal to diesel and electricity (intensity of steam locomotion in fact increased as steam engines began to be used increasingly for short haul movements, with several halts). The number of coal using steam locomotives reduced substantially, while the stock of diesel and electric locomotives increased. It is therefore clear that once all steam locomotives are out of service, further overall improvements may be possible only through design improvements and better management.

Table III.4.4: Electrified And Non-Electrified Rail Track (Kilometres)

	1970/71	1973/74	1976/77	1979/80	1982/83	1983/84	1985/86
a. Total Route-km	**59790**	**60234**	**60656**	**60890**	**61385**	**61460**	**61836**
a1 Broad Gauge	29449	30210	30873	31239	32624	32700	33669
a2 Metre Gauge	25865	25548	25512	25370	24515	24514	23921
a3 Narrow Gauge	4476	4476	4281	4281	4246	4246	4246
b. Total Track-km	**71669**	**74105**	**74840**	**75450**	**76197**	**105442**	**106502**
b1 Broad Gauge	40825	42756	43743	44410	46309	67377	69150
b2 Metre Gauge	26362	26873	26816	26759	25642	33299	32589
b3 Narrow Gauge	4482	4476	4281	4281	4246	4766	4763
c. Electrified Route -km	**3420**	**4190**	**4719**	**4820**	**5815**	**5971**	**6516**
c1 Broad Gauge	NA	4024	4553	4654	6649	5805	6350
c2 Metre Gauge	NA	166	166	166	166	166	166
d. Electrified Track -km	**NA**	**8402**	**9373**	**9562**	**11059**	**14860**	**16086**
d1 Broad Gauge	NA	8181	9152	9341	10838	14532	15758
d2 Metre Gauge	NA	221	221	221	221	328	328

Source: Railway Board (GOI), Indian Railways : Annual Statistical Statements, various issues.

Table III.4.5 : Number Of Operating Locomotives (As on March 31 of Each Year)

	1971	1974	1977	1980	1983	1985
Total	11158	11126	11095	11073	10087	10128
Steam	9387	8847	8345	7856	6292	5970
Diesel	1169	1610	1903	2243	2638	2905
Electric	602	669	847	974	1157	1253

Source: Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.6: Rail Freight Traffic
(net million t-km)

		1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a.	**Revenue Earning Traffic**	110698	109391	144031	144559	167780	196600
a1	Coal	27837	26587	38756	35340	47893	64401
a2	Raw Material for Steel plants	2708	2675	4639	4482	5379	5354
a3	Pig iron and finished steel from steel plants	6201	6179	9882	8063	10093	10406
a4	Iron ore for Export	5492	4275	6408	6188	5761	7273
a5	Cement	6990	6368	9170	7442	9159	11729
a6	Food grains	14505	16322	18757	23474	30417	32714
a7	Fertilizers	3808	4001	7225	9240	8252	14900
a8	Mineral Oils	5264	6373	7552	10398	11212	10959
a9	Other commodities	37891	36612	41641	39933	39614	38864
b.	**Non-Revenue Earning Traffic**	16662	12963	12725	11437	9986	9303
c.	**Total Traffic**	127358	122354	156756	155995	177766	205903

Source: Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.7 : Average Lead Distance Of Freight Moved By Rail (km)

		1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a.	**Revenue Earning Traffic**	659	675	677	749	733	760
a1	Coal	581	562	575	570	582	634
a2	Raw Materials for Steel plants	169	168	200	216	229	233
a3	Pig iron & finished steel from Steel Plants	993	1009	1000	1117	1207	1176
a4	Iron ore for export	560	506	644	667	582	580
a5	Cement	633	635	668	741	718	653
a6	Food grains	961	1114	940	1279	1231	1357
a7	Fertilizers	811	753	929	1122	969	1094
a8	Mineral Oils	559	638	609	729	647	588
a9	Other Goods	787	826	861	929	957	1017
b.	**Non-Revenue Traffic**	583	568	480	462	367	334
b1	Railway Coal	937	801	743	721	649	700
b2	Railway Stores & Materials *	109	50	246	229	239	228
b3	Diesel for Railways	-	538	472	561	537	443

* Railways stores and materials carried in other than departmental wagons and ballast trains.

Source : Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.8 : Rail Passenger Traffic

		1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a.	**Passengers Carried (million)**	**2431**	**2653**	**3300**	**3505**	**3656**	**3433**
a1	Suburban	1227	1437	1802	1903	2029	1884
a2	Non-suburban	1204	1216	1498	1602	1627	1549
b.	**Passenger km (billion)**	**118**	**135**	**163**	**198**	**227**	**240**
b1	Suburban	23	28	37	38	46	45
b2	Non-suburban	95	107	126	160	181	195
c.	**Average no. of km a passenger was carried**	**48.6**	**51.1**	**49.6**	**56.7**	**62.1**	**70.1**
c1	Suburban	18.8	19.5	20.6	20.4	22.6	24.1
c2	Non-suburban	78.9	88.5	84.6	99.8	111.4	126.0

Source: Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.9: Rail Freight and Non-Suburban Passenger Traffic

	Broad Gauge	Metre Gauge	Narrow Gauge	All
1970/71				
Total traffic (bgt-km)	305.756	73.608	2.062	381.43
- % Passenger	27.9	43.2	58.5	31.0
- % Freight	72.1	56.8	41.5	69.0
- % Steam	41.1	73.5	88.6	47.6
- % Diesel	38.8	25.1	11.4	36.0
- % Electric	20.1	1.4	-	16.4
1976/77				
Total traffic (bgt-km)	378.568	76.276	1.651	456.5
- % Passenger	27.6	44.5	61.5	30.5
- % Freight	72.4	55.5	38.5	69.5
- % Steam	25.2	57.7	80.0	30.9
- % Diesel	48.0	40.6	20.0	46.7
- % Electric	26.8	1.7	-	22.5
1982/83				
Total traffic (bgt-km)	435.294	70.419	1.51	507.22
- % Passenger	28.7	47.1	72.1	31.4
- % Freight	71.3	52.9	27.9	68.6
- % Steam	11.5	39.7	73.7	15.6
- % Diesel	57.3	58.6	26.3	57.4
- % Electric	31.2	1.7	-	27.0
1985/86				
Total traffic (bgt-Km)	509.879	72.186	1.463	583.528
- % Passenger	29.2	46.9	73.7	31.5
- % Freight	70.8	53.1	26.3	68.5
- % Steam	8.2	34.2	57.8	11.5
- % Diesel	58.2	64.1	42.2	59.0
- % Electric	33.6	1.7	-	29.5

Source: Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.10 : Energy Consumption In Railways

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a. Freight & non-suburban passenger traffic.						
- Coal (MMT)	14.3	12.7	12.2	11.4	9.4	8.6
- Furnace Oil ('000t)	NA	63	76	68	51	44
- Diesel Oils ('000t)	569	681	847	981	1227	1483
- Electricity (GWh)	NA	977	1447	1574	1876	3134
b. Electricity for (GWh) suburban passenger traffic	372	407	492	578	608	

Source: Railway Board (GOI), op cit Ref. Table III.4.4.

Table III.4.11 : Energy Intensity In Railways (toe / million gross t-km)

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a. All non-suburban passenger & freight traffic	21.4	20.9	16.8	15.7	12.3	10.1
a1 Steam	42.4	47.5	47.0	56.2	60.4	65.1
a2 Diesel	3.4	3.6	3.3	3.3	3.5	3.5
a3 Electric	3.6	3.7	3.5	3.9	3.4	4.1
b. Suburban passenger traffic	10.4	9.3	9.6	10.5	10.4	

Source : Railway Board (GOI), op cit Ref. Table III.4.4.

III.4c Road Transport

In contrast to the railway track network, the road network has increased considerably during the past two decades. Roads have been extended to rural and remote areas also, where road transport vehicles have become the only means of transport. Unlike the railways, this sector is not organized (perhaps because of the dual ownership pattern), and the data base is therefore rather weak. Firm and up-to-date information on ownership pattern for trucks (which are predominantly in the private sector) is lacking. The information base on passenger-km and freight tonne-km travelled is not too reliable. And the consumption of petroleum products is known only at an aggregate level-- no break-ups of petrol and diesel use by types of vehicles are available. Furthermore, at least for diesel, a certain (unknown) fraction may actually be consumed for agriculture.

For these reasons, it becomes difficult to estimate the relative shares of private and public modes of road passenger traffic. According to the Report of the Working Group on Energy Policy (GOI, New Delhi, 1979) the share of passenger traffic through private modes increased gradually upto the year 1978/79, when it was about 23%. Yet, with apparently "reasonable" assumptions regarding annual utilization rates and occupancy levels, the Department of Surface Transport GOI(1987), estimates that the share of private modes of transport has varied from 17% to 20% from 1970/71 to 1985/86. Estimates of the annual utilization patterns and occupancy ratios used for these computations are based on isolated sample surveys conducted in various cities/towns, and no time series data are available. Likewise for trucks, no reliable time series data are available on the origin/destination of freight carried, types of commodities and so forth.

Data on the energy consumption intensity by various types of motorized vehicles are available; but these intensity figures relate only to test conditions. It is known that petrol/diesel consumption intensity of vehicles is minimum only at a certain speed, and that too, on a smooth, flat, wide road. To the extent vehicles are driven at speeds below or above the optimal speed, and the roads are undulating and rough, the petrol/diesel consumption intensity may be higher.

Table III.4.12 : Road Length ('000 km)

	Surfaced	Unsurfaced	Total	National Highways
1960/61	234	471	705	23
1971/72	436	576	1012	28
1972/73	474	654	1128	29
1973/74	499	672	1171	29
1974/75	523	692	1215	29
1975/76	551	698	1249	29
1976/77	572	736	1308	29
1977/78	596	776	1372	29
1978/79	622	823	1445	29
1979/80	647	846	1493	29
1980/81	693	811	1504	32
1981/82	732	814	1546	32
1982/83	759	857	1616	32
1983/84	794	881	1675	32
1984/85	833	940	1772	32

Source : Centre for Monitoring Indian Econonmy (CMIE), Basic Statistics relating to the Indian Economy, vol. I All India, various issues.

Table III.4.13: Population of Registered Motor Vehicles in India ('000)

	Passenger Cars, Jeeps & Taxis	Buses	Trucks	Two Wheelers	Others	Total
1960/61	310	57	168	88	42	665
1965/66	465	73	259	226	85	1099
1970/71	682	94	343	576	170	1865
1971/72	740	100	364	656	185	2044
1972/73	709	95	308	734	263	2109
1973/74	768	105	323	838	293	2327
1974/75	766	114	335	946	311	2472
1975/76	779	115	351	1057	398	2700
1976/77	878	119	383	1415	465	3260
1977/78	919	124	403	1618	550	3614
1978/79	996	133	444	1888	598	4059
1979/80	1055	140	472	2115	732	4514
1980/81	1117	154	527	2528	847	5173
1981/82	1207	164	587	2963	922	5844
1982/83	1351	178	648	3512	1025	6719
1983/84	1424	196	719	4234	1168	7759
1984/85	1540	213	783	4960	1287	8796
1985/86	1627	230	848	5798	1379	9882

Source : CMIE, op cit Ref. Table III.4.12.

Table III.4.14 : Number Of Bicycles Manufactured In India('000)

Year	
1961/62	500
1964/65	800
1970/71	1700
1974/75	2000
1978/79	3500
1979/80	3830
1980/81	5100
1981/82	4830
1982/83	5460
1983/84	5950
1984/85	5830
1985/86	5700

Source : CMIE, Production and Capacity Utilization in 630 Industries, various issues.

Table III.4.15 : **Population Of Bicycles & Cycle Rikshaws In Selected Cities/ Towns ('000)**

City	Year	Population
Bicycles		
Delhi(a)	1971	625
Gurgaon(b)	1981	1100
Madras(c)	1983	560
Pune(d)	1980	600
Cycle Rikshaws		
Agra(e)	1977	18
Ahmedabad(e)	1977	2.1
Bangalore(e)	1977	4.1
Chandigarh(e)	1977	2.0
Delhi(f)	1977	5.1
Gurgaon(b)	1980	1.6
Hyderabad(g)	1970	13
	1977	14
	1981	18
Kanpur(h)	1984	35
Lucknow(e)	1977	22
Nagpur(e)	1977	5.9
Trivandrum(e)	1977	5.8
Vishakapatnam(e)	1977	4.2
Vijayawada(e)	1977	3.5
Warangal(e)	1977	2.0

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h. Central Statistical Organization, Statistical Abstract, India, 1979.

Table III.4.16 : Estimates Of Road Freight Traffic (billion tonne-km)

	1961	1970	1975	1980	1981	1982	1983	1984	1985
a. Trucks	27.1	59.3	82.3	134.6	156.3	178	198.4	214.1	237.5
- H.C.V.	26.5	57.9	80	130.8	152.1	173.4	193.2	208.2	230.9
- L.C.V.	0.6	1.4	2.3	3.8	4.2	4.6	5.2	5.9	6.6
b. Three Wheelers	0.02	0.09	0.22	0.51	0.62	0.71	0.81	1.05	1.25
c. Animal Drawn Carts	2.6	2.9	3.0	3.2	3.2	3.3	3.3	3.4	3.4
d. Agricultural Tractors	0.05	0.19	0.36	0.67	1.07	0.96	1.01	1.15	1.31

Source : Engineering Consultants Pvt. Ltd., op cit Ref. Table III.4.3.

Table III.4.17 : Estimates Of Road Passenger Traffic (Billion passenger km)

	1961	1970	1975	1980	1981	1982	1983	1984	1985
a. Private Motorized vehicles	13.4	26.5	41.4	65.0	72.3	79.8	90.8	103.0	114.8 *
- car/Taxis	12.4	21.7	30.7	42.2	44.7	48.4	54.1	59.9	64.3
- 2 Wheelers	0.7	3.3	7.0	15.6	18.7	21.9	26.0	30.5	35.7
- 3 Wheelers	0.3	1.5	3.7	7.2	8.9	9.5	10.7	12.6	14.8
b. Public Motorized Vehicles									
- Buses (Total)	81.4	189.1	292.8	420.9	543.2	594.7	597.1	674.3	738.9
- Buses (STUs)	24.8	72.7	118.7	203.9	225.0	248.0	263.7	276.2	292.4
c. Non-Motorized Vehicles									
- Cycle-Rikshaws	3.5	4.7	5.7	7.0	7.1	7.4	7.7	8.0	8.4
- Bicycles	5.7	13.5	21.8	35.1	38.7	42.5	46.8	51.5	56.6

Source : Engineering Consultants Pvt. Ltd., op cit Ref. Table III.4.3.

Table III.4.18 : Estimates Of Occupancy Of Trucks And Buses

Year	Trucks Average Load (Tonnes)	Buses Occupancy Ratio (%)
1951	4.12	45
1956	4.53	51
1961	4.98	59*
1966	5.47	60*
1971	6.01	73*
1972	6.12	71
1973	6.24	72
1974	6.36	73
1975	6.48	75
1976	6.60	76
1977	6.72	70*
1978	6.85	83*
1979	6.98	79
1980	7.11	77*
1981	7.25	86*
1982	7.25	86*
1983	7.25	84*
1984	7.25	84*
1985	7.25	86*

* Indicates actual data, rest are estimates.

Source : Engineering Consultants Pvt. Ltd., op cit Ref. Table III.4.3.

Table III.4.19 : Occupancy Of Various Vehicles

Study	City/Town	Occupancy	Remarks
1. Cars/Taxis			
a. Bombay Transportation Study.	Bombay	1.6	Cars (1979-82)
	Bombay	1.4	Taxis (1978-82)
b. Road User Cost Study.		2.7	For cars in suburban routes (1978-82)
	-	4.5	For cars in rural routes (1978-82)
2. Two Wheelers			
a. Working Group on Road Transport for the 7th Plan.	-	1.5	(1985-90)
b. Road Development Plan for India, Indian Roads Congress, New Delhi.	-	1.5	1981-2001
3. Three Wheelers			
a. Public Transport Supply in Indian cities, TRRL Report 1018, Transport & Road Research Lab Crowthorne.	Bangalore	1.5	1981
	Delhi	1.5	
	Jaipur	1.6	
b. Intermediate Public Transport Hyderabad, Area Transportation study, 17th Progress Report, Regional College of Engineering, Warangal.	Hyderabad	2.1	1985
c. I.A. Jenkins, Public Transport in India, Technical Report No. 29, Univ. of Newcastle.	Baroda	2.1	1978
4. Cycle Rikshaws			
	Agra	1.9	1981
a. Public Transport Supply in Indian cities, TRRL Report 1018 Transport & Road Research Lab. Crowthorne.	Delhi	1.5	
	Faridabad	1.4	
	Hyderabad	2.4	
	Jaipur	1.9	
	Kanpur	1.6	
	Meerut	1.6	
b. Intermediate Public Transport, Hyderabad Area Transportation Study, 17th Progress Report, Regional Colllege of Engineering, Warangal.	Hyderabad	1.56	1985

Table III.4.20 : Consumption Of Petroleum Products In Road Transport

Year	Petrol ('000t)	Diesel Oils ('000t)
1970/71	1453	NA
1975/76	1275	5093.25
1976/77	1316	5182.25
1977/78	1391	5304.0
1978/79	1499	5421.25
1979/80	1490	5622.5
1980/81	1522	6252.5
1981/82	1599	6580.0
1982/83	1722	6914.0
1983/84	1891	7295.0
1984/85	2084	NA
1985/86	2264	NA

Source : (i) Department of Petroleum, Indian Petroleum and Natural Gas Statistics, 1985-86; and (ii) Engineering Consultants Pvt. Ltd., op cit Ref. Table III.4.3.

Table III.4.21 : Intensity Of Various Vehicles

Vehicle	Optimum Speed (KMPH)	Fuel Consumption (cc/veh-km)
Scooter	-	18.7
Diesel Jeep	35	69.6
Ambassador Car	40	75.88
Premier Padmini Car	40	71.02
Tata Truck 1210 SE	45	133
Ashok Leyland Beaver Truck	35	305.72
Urban Bus (Diesel)	-	247.1
Regional Bus (Diesel)	-	225.36

Source : (i) Central Road Research Institute, Road User Cost Study in India, Final Report, 1982; and (ii) Planning Commission (1980), op cit Ref. Table III.4.1.

Table III.4.22 : Fuel Consumption* Of Different Vehicles Under Various Speeds

	Speed (km/hr)							
	10	30	35	40	45	70	90	100
Diesel Jeep								
- Fuel Consumption (cc/km)	-	72.2	69.6	71.1	-	130.8	-	-
- Fuel Consumption as % of optimum	-	103.7	100.0	102.2	-	187.9	-	-
Ambassador Car								
- Fuel Consumption (cc/km)	181.6	80.5	-	75.9	-	101.8	139.1	162.5
- Fuel Consumption as % of optimum	239.3	106.1	-	100.0	-	134.2	183.3	214.1
Premier Padmini Car								
- Fuel Consumption (cc/km)	89.7	71.3	-	71.0	-	79.2	89.3	95.6
- Fuel Consumption as % of Optimum	126.3	100.3	-	100	-	111.1	125.8	134.7
Tata Truck								
- Fuel Consumption (cc/km)	397	153	142	135	133	162	216	-
- Fuel Consumption as % of Optimum	298.4	115.4	106.8	106.5	100	121.8	162.4	-
Ashok Leyland Bearer Truck								
- Fuel Consumption (cc/km)	444.8	305.9	305.7	310.3	318.7	402.8	-	-
- Fuel Consumption as % of Optimum	145.5	100.1	100.0	101.5	104.3	131.8	-	-

* The above table gives the fuel consumption of the four vehicles when driving on a typical black-topped road on a level stretch at different speeds.

Source : Central Road Research Institute, op cit Ref. Table III.4.21.

III.4d Water Transport

Both inland water transport (IWT) and coastal shipping have played a limited role in India. Among the most important constraints is the vintage of existing fleet of tugboats, barges, tankers and other vessels.

IWT can take place only where rivers exist. However, the rivers may not be deep and/or wide enough to allow the use of mechanized water craft. Besides, some rivers may be used by mechanized craft only during and after the rainy season. The importance of IWT has declined also with the extension of road network and with the construction of bridges to facilitate river crossings by rail and road.

Coastal shipping also operates under various constraints. Although like IWT, it entails no investment in line haul facilities, loading and unloading operations at ports have been generally slow. Some ports however, have improved considerably in recent years. The Indian merchant fleet capacity has also increased rather steadily, and it now carries nearly 40% of India's overall cargo traffic for international trade.

The data base on freight tonne-km is not available from published sources. Furthermore, from the aggregate data on cargo handled at ports, it is not possible to distinguish between cargo imports, cargo for export, and cargo for movement from one port to another along the Indian coastline.

Besides, data on only total offtakes of petroleum products for coastal shipping are available, and it is therefore difficult to estimate the energy intensity of cargo haulage. Likewise, it is also difficult to analyze the energy intensity of freight movements in shipping for international trade. However, some normative data on energy consumption intensities for various types of vessels are available.

Table III.4.23 : Growth Of Indian Merchant Fleet

	Number of Ships	Gross registered tonnage ('000 tonnes)
1950	177	420
1960	257	859
1965	354	1523
1970	399	2402
1971	397	2478
1972	412	2650
1973	430	2887
1974	451	3485
1975	471	3869
1976	526	5094
1977	566	5482
1978	591	5759
1979	601	5854
1980	616	5911
1981	620	6020
1982	644	6213
1983	677	6227
1984	710	6415
1985	741	6605
1986	736	6540

Source : CMIE, op cit Ref. table III.4.12.

Table III.4.24 : Shipping Cargo Handled At Major Ports *
(million tonnes)

	1950/51	1960/61	1970/71	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Bombay	7.0	14.7	14.4	17.6	19.6	24.8	25.4	25.2	24.9
Calcutta & Haldia	7.6	9.5	6.0	9.3	9.8	10.5	10.9	10.2	12.1
Cochin	1.4	2.1	4.8	5.2	5.5	5.7	5.6	3.9	5.1
Kandla	-	1.6	1.6	8.8	9.5	12.6	13.7	15.7	16.5
Madras	2.2	3.0	6.9	10.4	11.4	12.4	12.8	15.0	18.2
Murmugao	-	-	11.0	13.9	14.9	12.8	12.8	14.5	16.1
New Mangalore	-	-	-	1.0	1.6	2.3	3.1	3.4	3.7
Paradip	-	-	2.2	2.3	2.2	1.6	1.6	2.1	3.3
Tuticorin	-	-	-	2.6	2.7	3.2	3.6	3.8	4.2
Vishakapatnam	1.0	2.9	8.8	10.2	10.9	10.2	11.1	12.9	15.9
Total	19.2	33.8	55.7	81.3	88.1	96.1	100.6	106.7	120.0

* Account for nearly 90% of total cargo handled at all ports.

Source : CMIE, op cit Ref. Table III.4.12.

Table III.4.25 : Self Reliance In Moving Cargo On Indian ships

Year	Share of Indian ships in overall overseas cargo traffic (%)
1955/56	6.5
1960/61	9.0
1965/66	12.9
1970/71	19.8
1975/76	35.1
1980/81	32.3
1981/82	31.4
1982/83	41.5
1983/84	40.9
1984/85	37.1
1985/86	34.7

Source : CMIE, op cit Ref. Table III.4.12.

Table III.4.26 : Commodity Composition Of Traffic At Major Ports

	1950/51	1955/56	1960/61	1965/66	1970/71	1975/76	1979/80	1984/85
Petroleum (%)	16.1	27.4	30.4	32.5	33.0	32.9	37.2	46.7
Iron Ore (%)	-	1.3	16.9	20.8	35.2	32.3	29.9	84.3
Coal (%)	14.1	11.1	5.5	4.0	1.3	1.8	2.5	4.7
Fertilizers (%)	1.6	1.8	1.6	3.3	4.3	5.2	7.7	5.6
Foodgrains (%)	17.7	3.5	13.2	14.8	5.7	10.4	1.3	0.9
Other Cargo (%)	50.5	54.9	32.4	24.6	20.5	17.4	21.8	17.8
Total (MMT)	19.2	22.6	39.5	50.5	55.7	65.4	78.0	107.0

Source : (i) Planning Commission, op cit Ref. Table III.4.1; and (ii) CMIE, op cit Ref. Table III.4.2.

Table III.4.27 : Fuel Deliveries Made to Coastal And International Bunkers
('000 tonnes)

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a. Coastal Bunkers	**240.9**	**187.3**	**211.3**	**196.7**	**301.0**	**307.0**
a1 Furnace Oil	196.9	144.0	153.1	126.4	172.2	169.2
a2 High Speed Diesel	22.4	23.7	32.2	41.9	81.0	97.7
a3 Light Diesel Oil	21.6	19.6	26.0	28.4	47.8	40.1
b. International Bunkers	**234.3**	**209.3**	**237.2**	**216.6**	**141.2**	**109.3**
b1 Furnace Oil	207.9	179.9	166.9	135.8	85.0	66.5
b2 High Speed Diesel	6.4	4.8	19.9	17.7	14.5	10.5
b3 Light Diesel Oil	20.0	24.6	50.4	63.1	41.7	32.3

Source : Department of Petroleum, op cit Ref. Table III.4.20.

Table III.4.28 : Intensity Of Water Traffic
(kgoe/t-km)

	Intensity	Remarks
Inland Water Transport		
1000 ton vessel	0.00677	50% Load factor
1000 ton vessel	0.00432	75% Load factor
1500 ton vessel	0.00449	50% Load factor
1500 ton vessel	0.00289	75% Load factor
Coastal Shipping		
14400 ton vessel	0.00373	Cargo : Coal
14400 ton vessel	0.00435	Cargo : Salt

Source: Planning Commission, op cit Ref. Table III.4.1.

III.4e Air Transport

India's three air carriers are Air India (international), the Indian Airlines (domestic) and Vayudoot (domestic). The Indian Airlines also operates on some medium distance international routes to adjoining countries. These air carriers are still not a major form of transport either for passenger or for freight traffic in India; although beginning from a small base, air traffic has grown very rapidly since the early 1970s.

Relevant information is available only for the Indian Airlines, which is the premier air carrier operating on domestic routes. Its fleet composition and capacity have changed significantly during the past fifteen years or so; a distinct trend is observed towards larger jet-engined aircraft. The share of passenger traffic carried through the latter aircraft has also increased rapidly. Consequently, the overall energy intensity has reduced. According to an estimate made by the Indian Airlines, the intensity reduced from 0.083 litres of ATF per available seat-km (lit/as-km) in 1970/71, to about 0.049 lit/as-km in 1982/83.

However, it is difficult to estimate energy intensity of the Indian Airlines from published sources. Data on ATF offtakes by the Indian airlines alone are seldom published. Only the total ATF offtakes by all three India's air carriers as well as by international airlines and other air services are available.

Table III.4.29 : Indian Airlines -- Revenue Flying Hours

Year	Total	A300B	Boeing 737	Others
1972/73	116077	-	17950	98127
1973/74	83501	-	13413	70088
1974/75	95105	-	17648	77457
1975/76	106189	-	30142	76047
1976/77	107156	2306	33975	70875
1977/78	106378	7929	34910	63539
1978/79	114391	11046	40847	62498
1979/80	106409	14157	35929	56323
1980/81	105703	16722	41717	47264
1981/82	104248	20267	44806	39175
1982/83	106662	23301	52182	31179
1983/84	109448	22778	60222	26448
1984/85	118910	24740	66919	27251
1985/86	127475	26908	72144	28427

Source : Indian Airlines, Annual Report, various issues.

Table III.4.30 : Air -- Passenger Traffic

	1972/73	1975/76	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
a. Revenue Passenger Carried ('000)	**2993.6**	**3367.3**	**5428.0**	**6189.0**	**6862.9**	**7681.2**	**8544.0**	**9172.8**
a1 Indian Airlines (domestic)	2824.7	3240.5	5079.7	5773.1	6405.9	7227.4	8082.7	8637.8
a2 Indian Airlines (international)	147.6	118.7	328.2	402.6	440.9	442.0	426.4	491.9
a3 Air India (domestic)	21.3	8.1	20.1	13.3	16.1	11.8	34.9	43.1
b. Revenue Passenger km(million) (Indian Airlines Only)	**2167.2**	**2609.2**	**4323.1**	**4902.6**	**5408.2**	**5994.2**	**6676.5**	**7336.4**

Source : Indian Airlines, op cit Ref. Table III.4.29.

Table III.4.31 : Occupancy Ratio (Indian Airlines)

Year	Available Seat-km (million)	Revenue Passenger-km (million)	Occupancy Ratio (%) All Types	A 300B	Boeing 737
1972/73	3479.0	2167.2	62.3	-	66.2
1973/74	2700.7	1904.4	70.5	-	69.0
1974/75	3216.2	2229.8	69.3	-	63.5
1975/76	3870.6	2609.2	67.4	-	64.4
1976/77	4128.8	2926.8	70.9	70.0	69.2
1977/78	4806.5	3388.8	70.5	71.2	67.9
1978/79	5568.9	4081.4	73.3	74.9	70.2
1979/80	5720.3	4199.1	73.4	76.8	68.6
1980/81	6466.1	4323.1	66.9	70.4	63.5
1981/82	7127.7	4902.6	68.8	69.8	67.7
1982/83	7965.4	5408.2	67.9	69.2	66.3
1983/84	8252.7	5994.3	72.6	76.8	69.3
1984/85	9042.9	6676.5	73.8	78.2	70.4
1985/86	9924.2	7336.4	73.9	79.1	69.8

Source : Indian Airlines, op cit Ref. Table III.4.29.

Table III.4.32 : Cargo And Mail Carried By Indian Airlines ('000 Tonnes)

Year	Cargo carried*	Mail Carried	Total
1972/73	26.6	14.1	40.7
1973/74	19.6	11.0	30.6
1974/75	20.0	11.4	31.4
1975/76	24.3	12.6	36.9
1976/77	28.2	12.9	41.1
1977/78	37.6	13.6	51.2
1978/79	48.6	14.6	63.2
1979/80	50.9	14.6	65.8
1980/81	58.3	15.7	74.0
1981/82	69.8	16.4	86.2
1982/83	77.9	16.1	94.0
1983/84	94.1	17.1	111.2
1984/85	109.5	17.7	127.2
1985/86	111.2	18.3	129.5

* Includes excess baggage.

Source : Indian Airlines, op cit Ref. Table III.4.29.

Table III.4.33 : ATF Offtake
('000 tonnes)

Year	
1970/71	689
1973/74	800
1976/77	956
1979/80	1144
1982/83	1145
1983/84	1208
1984/85	1336
1985/86	1440

Source: Department of Petroleum, op cit Ref. Table III.4.20.

Table III.4.34: Energy Intensities of Various Aircrafts

	Intensity (litre/available seat-km)	Available Seats
Airbus	0.042	278
Boeing 737	0.055	126
Turbo	0.075-0.080	40,48, <100

Source: Planning Commission, op cit Ref. Table III.4.1.

III.5 RESIDENTIAL SECTOR

III.5a Energy Consumption Mix

The residential sector is the largest consumer of energy, accounting for approximately 50% of the energy consumption in the country. A large fraction of the energy used in households comprises traditional fuels, such as fuelwood, animal dung and crop residues. The data base is therefore quite inadequate, although some indicative data, gathered through field surveys, are available. The data presented in survey reports are not based on actual measurements, but solely on the "impressions" of the quantity used.

Therefore, the information thus gathered may be considered to be only of a qualitative nature which also gives considerable insight regarding the energy consumption pattern in households. Field surveys to date have indicated broadly that: (i) per capita energy consumption increases with a rise in income and expenditure levels; and (ii) the share of commercial energy in the total consumption mix increases with income and expenditure levels, as also with the size of town and city. However, the rise in per capita energy consumption with expenditure levels is shown to be relatively more in urban areas. This may reflect the fact that a significantly higher proportion of energy used in rural areas may be collected at zero private cost, a practice which is normally not possible in urban areas.

Not only are there significant urban-rural differences in how energy supplies for households are obtained, but also how energy is consumed. Moreover, the energy consumption mix itself may change over time. Some of these aspects are highlighted in subsequent sections.

Table III.5.1: Index of Per-Capita Energy Consumption

a. For 1973-74 *

Monthly per-capita expenditure class (Rs.)	Rural	Urban
< 21	66	48
21 - 28	80	61
28 - 43	90	82
43 - 75	101	96
> = 75	138	125
All Classes	100	100

b. For 1978-79 **

Annual Household Income Category (Rs.)	Rural	Urban
< 3000	98	86
3001 - 6000	96	95
6001 - 12000	112	113
12001 - 18000	125	134
> 18000	127	133
All Classes	100	100

* Source: National Sample Survey 1973/74, 28th Round; as quoted in Govt. of India, Report of the Working Group on Energy Policy, New Delhi, 1979.

** Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table III.5.2: Commercial and Non-Commercial Energy Consumption in Rural and Urban Areas in 1978/79

Annual Household Income Category (Rs)	Rural Total (mtcr)	Rural Commercial (%)	Rural Non-Commercial (%)	Urban Total (mtcr)	Urban Commercial (%)	Urban Non-Commercial (%)
0 - 3000	45.8	9.2	90.8	8.3	33.9	66.1
3001 - 6000	32.0	11.0	89.0	14.7	55.0	45.0
6001 - 12000	14.2	13.7	86.3	10.4	69.9	30.1
12000 - 18000	2.3	14.4	85.6	17.8	77.1	22.9
> 18000 *	1.8	17.1	82.9	1.8	84.7	15.3
All Classes	96.0	10.7	89.3	36.9	56.9	43.1

1. mtcr: Million tonnes of coal replacement.

2. The following factors are used to convert fuel consumption from physical units to mtcr units:

Soft Coke/Coal :	1MMT	= 1.5 mtcr
Kerosene (for lighting) :	1 million kilolitre	= 2.086 mtcr
Kerosene (for cooking) :	1 million kilolitre	= 5.623 mtcr
LPG :	1MMT	= 10.184 mtcr
Electricity :	1000 GWh	= 0.706 mtcr
Firewood :	1MMT	= 0.655 mtcr
Charcoal :	1MMT	= 1.807 mtcr
Dungcakes :	1MMT	= 0.301 mtcr
Crop Residues :	1MMT	= 0.527 mtcr

Source: NCAER, op cit Ref. Table III.5.1.

Table III.5.3: Estimates of Annual Per-Capita Energy Consumption in Rural Areas

	Units	1962(a)	1963/64(a)	1973/74(a)	1978/79(b)
A. Commercial Fuels					
Coal/Soft Coke	kg	3.8	5.2	6.8	2.3
Kerosene (total)	litre	5.8	4.4	8.8	5.1
- Kerosene for lighting	litre	NA	NA	NA	4.3
- Kerosene for Cooking (c)	litre	NA	NA	NA	0.8
LPG	kg	---	---	---	0.01
Electricity	kWh	0.5	0.3	2.2	4.9
B. Traditional Fuels					
Fuelwood	kg	234.7	270.1	251.9	40.9
Charcoal	kg	0.6	0.7	0.1	0.2
Dungcakes	kg	126.8	100.8	72.7	133.1
Other Solid Fuels (d)	kg	72.3	9.8	12.4	176.9

a. As quoted in Ashok V. Desai, Inter-Fuel Substitution in the Indian Economy, Discussion Paper D-73 B, Resources for the Future, Washington, D.C., 1981.

b. NCAER, op cit Ref. Table III.5.1.

c. Also includes water heating and space heating.

d. Includes crop wastes, sawdust, woodshaving, twigs, leaves etc.

Note: 'Fuelwood' and 'Other Solid Fuels' may be clubbed together in order to facilitate a comparison of estimates of per-capita non-commercial energy consumption.

Table III.5.4: Estimates of Annual Per-Capita Energy Consumption in Urban Areas

	Units	1963/64(a)	1973/74(a)	1978/79(b)
A. Commercial Fuels				
Coal/soft Coke	kg	29.8	33.4	31.3
Kerosene (total)	litre	10.2	14.0	11.6
- Kerosene for lighting	litre	NA	NA	2.6
- Kerosene for cooking(c)	litre	NA	NA	9.0
LPG	kg	---	---	2.2
Electircity	kWh	9.0	18.2	35.0
B. Traditional Fuels				
Fuelwood	kg	169.3	148.6	82.8
Charcoal	kg	4.4	2.6	3.8
Dung Cakes	kg	33.3	25.2	35.7
Other Solid Fuels(d)	kg	3.5	4.9	41.5

a, b, c, d: Refer to Table III.5.3.

Note : 'Fuelwood' and 'Other Solid Fuels' may be clubbed together in order to facilitate a comparison of estimates of per-capita non-commercial energy across the years.

Table III.5.5: Estimates of Annual Per-Capita Energy Consumption in Metropolitan Cities

	Units	Delhi 1958	Calcutta 1958(a)	Bombay 1958(a)	Bombay 1972(b)	Delhi 1978/79
A. Commercial Fuels						
Coal/Soft Coke	kg	54.6	84.0	26.7	3.0	67.7
Kerosene (total)	litre	8.9	8.6	31.1	34.3	19.0
- for lighting	litre	2.5	4.5	2.9	NA	0.2
- for cooking(c)	litre	6.4	4.1	28.2	NA	18.8
LPG	kg	---	---	---	8.8(d)	5.7
Electricity (total)	kWh	52.3	53.7	37.9	108.5	90.6
- Electricity for lights and fans	kWh	29.0	41.3	29.5	NA	61.0(e)
- Electricity for other uses	kWh	23.3	12.4	8.4	NA	29.6
B. Traditional Fuels						
Fuelwood	kg	18.7	28.8	28.7	9.7	6.7
Charcoal	kg	10.9	2.47	2.7	6.0	---
Dungcakes	kg	14.4	6.7	0.6	(f)	1.9
Other Solid Fuels(g)	kg	NA	8.9	0.8	7.0	12.3

a. Survey done during summer months.
b. Survey done in an unspecified month.
c. Also includes water heating and space heating.
d. In cubic metres.
e. For lighting only.
f. Included in other solid fuels.
g. Comprises crop wastes, straw, twigs, leaves etc.

Source: For Delhi (1978-79), NCAER, op cit Ref. Table III.5.1; For Others, as quoted in Ashok V. Desai (1981), op cit Ref. Table III.5.3.

Table III.5.6: Per Capita Consumption of Energy By Size of Town and By type of Fuel

	Over 5 lakhs	2-5 lakhs	1-2 lakhs	0.5-1 lakh	0.2-0.5 lakh	Upto 0.2 lakh
All Fuels (kgcr*)	294	275	269	263	243	243
- % Non-Comm. Energy (%)	24.59	33.84	42.52	44.43	62.48	60.94
- % Comm. energy (%)	75.41	66.16	57.48	55.57	37.57	39.06
- Firewood (%)	17.65	20.67	29.64	31.82	38.56	32.92
- Soft Coke (%)	17.29	14.24	21.31	22.48	18.84	14.32
- Kerosene (%)	28.87	28.62	19.76	18.74	9.51	16.57
- Electricity (%)	13.47	9.37	9.22	8.00	6.32	6.67
- LPG(%)	15.58	12.7	7.19	6.35	2.89	1.47
- Others (%)	7.41	14.4	12.88	12.61	23.88	28.15

* kgcr : kilogram of coal replacement.

Source: TERI, Report on Energy in the Context of Urbanisation, prepared for the National Commission of urbanisation, Ministry of Urban Development, New Delhi, Aug. 1987.

III.5b Shifts in Energy Consumption Mix

Changes in energy consumption over time are determined by several factors including family size, fuel availability, relative prices of various fuels, and so on.

The NCAER collected some information to establish the broad trends in energy consumption during the five year period 1974/75 to 1978/79. The data that are available relate only to the number of househoulds using a particular type of fuel, and not to the actual or estimated quantities of fuels used. The available data indicate a distinct shift away from firewood in both urban and rural areas. While the fraction of households using LPG increased substantially in urban areas, in rural areas the use of biogas increased. The fraction of households using LPG increased substantially in urban areas, in rural areas the use of biogas increased. The fraction of households using soft-coke also is shown to have increased gradually from 1974/75 to 1978/79, in both rural and urban areas.

Further information on fuel shifts in urban households between 1978/79 and 1983/84 is also available. The trend of a decline in the use of firewood is clearly evident. However, the use of soft-coke is also reported to have declined, but this may be due to its decreasing supplies. The use of kerosene and LPG is shown to have increased substantially; the latter, particularly in the high expenditure category households.

Despite these shifts, there is little evidence that households now use the fuel they prefer for cooking. High cost or/and inadequate availability are perhaps the most important reasons for using a fuel which may not be preferred. A rise in income however, is revealed to be the most significant reason for shifting to commercial fuels for cooking.

Table III.5.7: Break-up of Households as per Cooking Fuel (% of households)

	Coal/ Soft-Coke	Kerosene	Firewood	LPG	Gobar Gas	% of households for which data are not available
Rural Areas						
1974	---	6.82	64.19	0.77	---	28.22
1979	4.92	5.13	9.64	0.70	37.13	42.48
Urban Areas						
1974	26.57	10.88	47.01	4.04	---	11.50
1979	30.47	16.76	7.86	32.16	0.20	12.55

Source: NCAER, op cit Ref. Table III.5.1.

Table III.5.8: Fuel Shares for Cooking and Heating -- By Income (%)

Income		Low (< 3000)	Low -Middle (3000 -6000)	Middle (6000 -12000)	High -Middle (12000- -18000)	High (>=18000)	All
Firewood	1978/79	60	40.9	25.1	17.4	12.1	42.4
	1983/84	53.5	30.8	17.9	9.9	9.6	27.4
Soft Coke	1978/79	12.8	20.2	23.6	16.7	17.3	18.4
	1983/84	6.4	18	17.9	15.2	8.3	15.3
Kerosene	1978/79	13.2	21.3	21.5	22.0	18.9	18.7
	1983/84	23.8	36.9	40.2	38.2	32.8	35.7
LPG	1978/79	0.8	4.6	14.2	26.9	32.9	6.6
	1983/84	1.2	4.6	15.7	27.9	39.3	11.5
Other	1978/79	13.3	13.1	15.6	17.0	18.8	13.9
	1983/84	15.2	9.7	8.3	8.8	10.1	1.01
No. of Households ('000)	1979	7286	9895	4792	611	524	23108
	1984	4885	9298	9742	2598	1193	27716

a. Income categories are in thousands 1978-79 rupees per year.
b. Shares are on a coal replacement basis for cooking and heating.

Source: TERI, op cit Ref. Table III.5.6

Table III.5.9: Reasons for Not Using Preferred Fuel for Cooking (% of Households)

Preferred Fuel	Reason for not using preferred fuel: Costly	Not Easily Available	Others	% of households not using preferred fuel, prefer*
Rural				
Soft Coke	34.01	57.92	8.07	19.65
Kerosene	66.74	33.17	0.09	17.27
Electricity	79.70	---	20.30	1.80
Firewood	25.26	60.88	13.86	14.20
LPG	19.20	78.25	2.55	29.19
Urban				
Soft Coke	48.60	31.49	19.91	6.61
Kerosene	69.71	29.70	0.59	7.71
Electricity	72.49	13.63	13.88	1.62
Firewood	67.97	7.93	24.10	2.32
LPG	18.86	74.58	6.56	78.51

* May not add upto 100, because several other fuels are also used in certain households.

Source: NCAER, op cit Ref. Table III.5.1.

Table III.5.10: Reasons for Shifting to Present Fuel for Cooking - All India (% of households)

	Rise in Income	Fall in Income	Present Fuel has Become Cheaper	Present Fuel not available 5 yrs ago	Present Fuel is more easily available	Other reasons	Total
Rural							
Soft Coke	72.63	--	15.59	11.78	--	--	100
Kerosene	30.91	--	9.64	--	59.45	--	100
Electricity	--	--	--	--	--	--	--
Firewood	91.79	--	8.21	--	--	--	100
LPG	66.67	--	--	33.33	--	--	100
All Fuels	20.04	9.30	4.68	12.71	15.09	38.18	100
Urban							
Soft Coke	17.81	3.51	28.18	11.96	18.05	20.49	100
Kerosene	49.91	8.24	2.27	12.74	5.15	21.69	100
Electricity	100.0	--	--	--	--	--	100
Firewood	4.67	22.69	--	--	12.08	60.56	100
LPG	36.7	--	4.83	35.27	13.24	9.96	100
All Fuels	30.69	4.23	11.03	19.33	13.39	21.33	100

* Present refers to the year 1978-79.

Source: NCAER, op cit Ref. Table III.5.1.

III.5c End Uses

While traditional energy fuels are normally used for cooking, water-heating and space-heating, commercial energy forms may be used for lighting, cooking and running other appliances (such as refrigerators, television sets etc.) as well. At the aggregate, all India level, the survey conducted by the NCAER reveals that in 1978/79, the share of total energy used for cooking, water heating and space-heating decreased with a rise in income levels in both rural and urban areas.

For commerical energy sources alone, their respective shares for these same end-uses increased with income levels in rural households; although no such trend was evident in urban households.

Furthermore, it is important to note that the total energy consumption data itself may not be a useful indicator, and that the "useful energy" consumption is more relevant. However, the latter may be determined only by measuring the efficiencies of various household appliances. In the absence of such measurements, some normative average efficiency figures (Table III.5.13) may be used.

Table III.5.11: Use of Commercial Energy for Cooking and Lighting in Rural & Urban Areas in 1978/79

Annual Household Income category (Rs)	Rural			Urban		
	Total ('000 tcr)	% for Cooking	% for Lighting	Total ('000 tcr)	% for Cooking	% for Lighting
0-3000	4190.971	33.7	66.3	2820.353	78.3	21.7
3001-6000	3521.332	41.3	58.7	8059.603	84.6	15.4
6001-12000	1946.745	52.7	47.3	7230.658	86.5	13.5
12001-18000	326.466	55.2	44.8	1369.735	86.0	14.0
>=18000	307.388	61.2	38.8	1488.129	84.8	15.2

Note: Cooking includes water heating and space heating. Lighting includes the use of fans, refrigerators, television sets and other electrical appliances.

Note: All Commercial energy consumption for the two end-uses is first expressed in `mtcr' units. Only then is it possible to estimate the percentage of commercial energy use in the two major end-uses.

Source: NCAER, op cit Ref. Table III.5.1.

Table III.5.12: Use of Commercial and Traditional Energy for Cooking and Lighting in Rural and Urban Areas in 1978/79

Annual Household Income category (Rs)	Rural			Urban		
	Total ('000 tcr)	% for Cooking	% for Lighting	Total ('000 tcr)	% for Cooking	% for Lighting
0-3000	45780.912	90.4	9.6	8316.976	87.2	12.8
3001-6000	31963.919	89.5	10.5	14664.046	85.1	14.9
6001-12000	14170.641	88.8	11.2	10350.890	82.7	19.6
12001-18000	2265.293	88.3	11.7	1777.074	80.4	19.6
>=18000	1799.243	88.2	11.8	1757.413	77.0	23.0

Source: NCAER, op cit Ref. Table III.5.1.

Table III.5.13 : Average Efficiency of Utilization of Cooking Fuels

Commercial Fuels	
Soft Coke/Coal	10
Kerosene (in pressure stove)	56
Kerosene (in wick stove)	42
LPG	63
Non-Commercial Fuels	
Firewood (in closed hearth)	16
Firewood (in open hearth)	13
Twigs and Straw (in closed hearth)	16
Twigs and Straw (in open hearth)	13
Charcoal	16
Dungcakes	8

Source : NCAER, Energy Demand in Greater Bombay. New Delhi, 1975.

III.5d Published Data on Residential Energy Consumption

As noted in section III.5a, information on household energy consumption patterns is available only from sample surveys, which may not be too reliable, considering that all surveys suffer from one major drawback that energy use is not actually measured while conducting the survey. Therefore, it becomes relevant to compare the data available from field surveys, with official estimates of energy sales to households. Of course, such a comparison is possible only for commercial energy forms: soft coke, kerosene and electricity.

The findings of three surveys may be compared with official estimates of energy consumption. It may be observed that while the surveys in 1963/64 and 1973/74 underestimated electricity consumption substantially, the survey in 1978/79 overestimated the use of softcoke. There seems to be a fair measure of agreement in the utilization of other fuels. With this observation, it becomes clear that survey estimates for utilization of traditional fuels may at best be considered to provide only qualitative information.

Likewise, production data for household appliances/devices are also available. Again, such data may not reveal exactly the population of appliances used in households because : (i) available data may not include the production/output of certain small manufacturers; (ii) a certain unknown fraction of the population of devices may in reality be used in commercial establishments; and (iii) the useful life span of many of these appliances may be difficult to determine.

Table III.5.14 : Total Annual Commercial Energy Consumption -- A Comparison of Survey Estimates

	Units	1963/64	1963/74	1978/79
Survey Estimates				
Soft - Coke	`000 t	2081	3285	5483
Kerosene	`000 t	2381	4674	3376
Electricity	GWh	883	3147	7317
Official Estimates(a)				
Soft - Coke	`000 t	2279	2911	2680
Kerosene	`000 t	2437	3451	3312
Electricity	GWh	2062	4645	7577

a. Based on production and sales data.

Source: For survey estimates, 1963-64 and 1973-74: As quoted in Ashok V. Desai (1981), op cit Ref. Table III.5.3.; for 1978-79: Survey Estimates NCAER (1981) ; op cit Ref; Table III.5.1; and for official estimates from: (i) Dept. of Petroleum, Indian Petroleum and Petrochemical Statistics, G.O.I., New Delhi (ii) CEA, Public Electricity Supply: All India Statistics-- General Review, New Delhi; and (iii) Coal Controller's Organisation, All India Annual Coal Statistics, Calcutta, various issues.

Table III.5.15: Official Estimates for Commerical Energy Consumption.

	Soft Coke (MMT)	LPG (MMT)	Kerosene (MMT)	Electricity (GWh)
1972/73	3.16	NA	3.492	4309.01
1973/74	4.65	NA	3.300	4644.55
1974/75	4.02	NA	2.895	5172.79
1975/76	3.63	0.266	3.104	5821.35
1976/77	4.02	0.27	3.322	6336.56
1977/78	3.54	0.29	3.634	6821.31
1978/79	2.68	0.302	3.952	7575.66
1979/80	3.38	0.332	3.872	8402.23
1980/81	3.05	0.327	4.228	9246.43
1981/82	3.02	0.424	4.693	10439.62
1982/83	2.34	0.53	5.214	12091.63

Source: op cit Ref. Table III.5.14.

Table III.5.16 Production of Selected Household Appliances ('000)

	1970	1975	1980	1983	1985	1986
a. Incandescent Lamps	10300	12900	20100	27200	27100*	28400*
b. Electric Fans	1570	1310	4120	4610	5200*	4700
c. TV Sets	5.1	39.4	86.8	155	2480**	3000**
d. Refrigerators	65.4	108.9	278.0	465.2	677.6*	591.4*
e. Portable Room Air - Conditioners	17	9.0	26.2	26.9	31.0	39.5

* Data refers to financial year.

** Production of large, medium and small scale units.

Source: Centre for Monitoring Indian Economy, Production and Capacity Utilization in 600 industries (1970 to 1986), October, 1987.

III.6 COMMERCIAL/SERVICES/GOVERNMENT SECTOR.

Schools, hospitals, private businesses, hotels, restaurants, Government buildings, offices and other energy consuming centres not included in agriculture, industry, transport and residential sectors comprise the commercial/ services sector.

A wide variety of energy consuming end-use activities characterize this sector. These include cooking, lighting, space heating, space cooling, refrigeration and pumping. Readily available energy consumption data are not disaggregated in general, either by end-use or by type of establishment. Only published electricity consumption statistics are disaggregated as per water and sewage supply works, street lighting, commercial buildings and miscellaneous. For other fuels, it may be best to rely on information gathered through isolated sample surveys.

The sector however, is not a major energy consumer. Its energy consumption intensity was only 4.4 mtoe/Rs'00 billion (1970/71 prices) as compared to about 20 mtoe/Rs'00 billion for the industrial sector. It may also be noted that in replacement units, the energy intensity of the sector has centred around 12 mtcr/Rs'00 billion since the early 1970s.

Table III.6.1: Commercial/Services Sector -- Gross Value Added (Rs. million, 1970/71 Prices)

	1970/71	1973/74	1976/77	1979/80	1982/83	1984/85
a. Trade, Hotels & Restaurants	40425	43130	52510	58159	69876	76346
b. Banking & Insurance	6563	7790	10130	12580	15945	19368
c. Real Estate, Ownership of Dwelling & Business Services	14575	15700	17110	20069	22466	24256
d. Public Administration & Defence	16350	19800	23700	31430	43790	55170
e. Other Services	16787	17820	19340	21958	24727	27604
f. Total	94700	104240	122790	144196	176804	202744

Source: Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, various issues.

Table III.6.2: Electricity Consumption in Commercial Sector (GWh)

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86
a. Commercial Establishments	2572.66	2987.52	4141.92	4656.58	5846.25	7761.61
b. Public Lighting	492.66	552.83	594.24	711.62	835.79	1080.15
c. Public Water Works & Sewage Pumping	1016.51	1116.96	1444.13	1407.76	1757.36	2129.91
d. Miscellaneous	381.67	622.15	697.74	1196.80	1640.74	1741.97
e. Total	4463.50	5279.46	6878.03	7972.76	10080.14	12713.64

Source: (i) CEA, Public Electricity Supply, All India: General Review, various issues; and (ii) CMIE, Current Energy Scene in India, May 1987.

Table III.6.3: Estimated Fuel Consumption in Commercial/Services Establishments in Rural Areas (1978/79)

	Livestock Forestry & Allied Activities	Manufacturing, Servicing, Processing & Repair	Trade and Commerce	Communication	Other	Total
Coal/Coke ('000 tonnes)	--	4492.3	133.8	0.3	56.7	4683.1
HSD ('000 kl)	--	67.0	--	--	--	67.0
Furnace Oil ('000 kl)	--	4.7	--	--	--	4.7
Kerosene ('000 kl)	88.6	97.7	248.2 (a)	3.4	154.2	592.1
Electricity (GWh)	--	1517.8	481.1	7.2	386.7	2392.8
Firewood ('000 tonnes)	--	1685.6	625.6	--	374.3	2685.5
Charcoal ('000 tonnes)	--	371.2	9.5	--	77.6	458.3
Veg. Wastes ('000 tonnes)	--	229.0	75.8	--	--	304.8

a. Includes 96,200 kilolitres used for heating/cooking in hotels and restaurants.

Source: NCAER (1981), op cit Ref. Table III.5.1.

Table III.6.4: Estimated Fuel Consumption in Commercial/Service Establishments in Urban Areas (1978/79)

	Hotels & Restaurants	Hospitals	Laundries	Others	Total
Coal/Coke ('000 tonnes)	644.9	22.1	49.7	--	716.7
LPG ('000 tonnes)	60.23	2.55	--	--	62.78
Kerosene ('000 kl)	164.0	21.3	14.9	13.3	213.5
Electricity (GWh)	406.8	213.2	149.7	--	769.7
Town gas ('000 cu.m.)	19.4	2.9	--	--	22.3
Firewood ('000 tonnes)	805.8	27.6	106.1	--	939.5
Charcoal ('000 tonnes)	176.6	6.9	51.5	--	235.0
Crop Wastes ('000 tonnes)	166.4	--	--	--	166.4

Source: NCAER (1981), op cit Ref. Table III.5.1.

Table III.6.5: Energy Consumption in Commercial/Services/Government Sector (1981/82)

	Units	1981/82
Energy Consumption		
- Coal *	MMT	5.91
- Electricity	GWh	7362
- LPG	'000 t	17
- Kerosene *	'000 t	844
- Furnace Oil	'000 t	1766
Total energy Cons.	mtoe	7.4
Share of		
- Coal	%	39.3
- Electricity	%	25.0
- LPG	%	0.2
- Kerosene	%	11.5
- Furnace Oil	%	24.0
Value Added	Rs.'00 billion	1.67
Intensity	mtoe/Rs.'00 billion	4.4

* Estimates based on NCAER (1981). Soft-coke/coal and kerosene consumption are split between residential and commercial sectors in the same ratio as in 1978/79.

mtoe: million tonnes of oil equivalent.

Source: (i) Department of Petroleum, Indian Petroleum and Petrochemical Statistics, GOI, various issues; (ii) Coal Controller's Organisation, Coal Statistics, GOI, various issues; (iii) CEA, Public Electricity Supply: All India Statistics, various issues; and (iv) CSO, National Accounts Statistics, GOI, various issues.

Table III.6.6: Energy Consumption on Commercial/Services/ Government Sector(1972/73 to 1981/82)

	Unit	1972/73	1976/77	1981/82
Energy Consumption				
- Coal *	MMT	384	3.98	5.91
- Electricity	GWh	3693	5434	7362
- LPG	`000 t	11.0	19.0	17.0
- Kerosene *	`000 t	556	538	844
- Furnace Oil	`000 t	1576	1622	1766
Total Energy Cons.	mtcr	12.97	14.34	19.73
Share of				
- Coal	%	29.6	27.7	30.0
- Electricity	%	20.1	26.7	26.3
- LPG	%	0.9	1.4	0.9
- Kerosene	%	26.2	22.5	25.7
- Furnace Oil	%	23.2	21.7	17.1
Value Added	Rs.`00 billion (1970/71 pr.)	1.03	1.25	1.67
Intensity	mtcr/Rs.`00 billion	12.5	11.5	11.8

* Estimates based on NCAER (1981). Soft-coke/coal and kerosene consumption are split between residential and commercial sectors in the same ratio as in 1978/79.

mtcr: million tonnes of coal replacement.

Source: Refer to Table III.6.5.

IV. ENERGY COSTS AND PRICES

IV.1 Energy Pricing Principles and their Applications

The basic principle of pricing any energy product, is that its price should reflect its opportunity cost to the country. For most energy products, this translates into the highest price for which they may be traded either within the country, or with other countries. It is only when a particular energy product cannot be traded, or cannot be used to substitute another product which is tradeable, that the opportunity cost of the product, and therefore its price, needs to reflect its cost of production or replacement.

Although this basic principle of energy pricing is widely accepted, it is often difficult to apply because of rapidly changing conditions of supply and demand which characterize the energy products themselves, as well as of the economies in which they are used. Moreover, as energy pricing decisions may also have widespread implications for other economic sectors, the decisions need to be taken within the framework of the national development policy and social development objectives.

It is for such reasons that energy prices are administered in most countries including India; and do not reflect the opportunity cost to the country. In fact, some energy products have usually been subsidized to such an extent that the supply industry has not been able to generate adequate resources internally to expand rapidly enough to keep pace with rising demand. Shortages of coal and power supplies have thus emerged in India over the past decade.

Against this background, a knowledge of opportunity costs of supplying any energy product is essential to an energy planner. Only with such information, the energy prices may gradually be shifted towards reflecting the economic supply costs. With these prices, it is hoped that consumers will receive appropriate signals to align their energy consumption pattern (over a reasonable period of time) with the indigenous energy resource endowments and international energy market conditions. However, such economic cost data are not usually documented; at most, financial cost data are available.

Furthermore, due to the high degree of substitutability, it is important to take an integrated approach and view the problem of energy pricing across products. The use of soft-coke, kerosene and LPG for cooking, coal and fuel oil in industrial boilers, and diesel oil and electricity for rail traction are examples of the extent to which energy products may substitute each other if the consumer invests in appropriate capital stock.

IV.2 Coal Pricing

The Indian coal industry has incurred heavy losses during the past decade. Coal prices have been set below production costs, and also far below the price of fuel oil -- its major substitute (for application in industrial boilers). Some justification may however, be advanced for keeping coal prices below fuel oil prices on a thermal equivalent basis: (i) strategic considerations, to reduce dependence on an imported fuel; and (ii) social considerations, arising from the fact that the price differential between the two fuels is so high that nullifying it would create strong inflationary pressures with immense social costs. On the other hand, pricing coal below production costs is difficult to justify.

In fact, there seem to be certain flaws in the methodology adopted for fixing coal prices. Coal production costs of all mines are averaged, which allows uneconomic mines to co-exist with economic production centres. As costs are averaged, losses in individual mines are ignored, and proper identification of mines for priority investments is not possible. Likewise, as all costs incurred by each mine are taken into account while estimating average costs, due attention is not paid to the inefficiencies inherent in the operations of certain mines. Inefficient mining practices therefore, continue.

Moreover, the entire pricing procedure focuses only on pithead costs, regardless of the cost of coal delivered to the consumer. Transportation charges, royalty and cesses, which are included in the consumer price, are not adequately considered. Consequently, the grade-wise price differential (at the pithead) becomes meaningless at the consumers' end; due largely to the high cost of transportation. Consumers therefore prefer to use high grades of coal (which are scarce) and there is little incentive to switch to inferior grades.

Table IV.2.1: Average Pithead Price of Coal (Rs/tonne)

1960	20.75
1965	23.78
1970	35.68
1972	36.41
1974	51.46
1976	70.14
1978	70.37
1980	118.95
1982	157.26
1984	204.87
1986	208.00

Source: Centre For Monitoring Indian Economy, Basic Statistics Relating To The Indian Economy, Vol.1: All India, August, 1987.

Table IV.2.2: Price of Non-Coking Coal

Grade	Useful Heat Value (kCal/kg)	Sale price of slack coal (Rs/tonne)
I. Coal produced in all States *		
Grade A	> = 6200	299.0
Grade B	5600 - 6200	272.0
Grade C	4940 - 5600	238.0
Grade D	4200 - 4940	212.0
Gtade E	3360 - 4200	141.5
Grade F	2400 - 3360	111.5
Grade G	1300 - 2400	77.5
II. Coal produced in Singareni Coalfields		
Grade C	4940 - 5600	335.5
Grade D	4200 - 4900	295.5
Grade E	3360 - 4200	255.5
Grade F	2400 - 3360	186.5
Grade G	1300 - 2400	146.5
III. Coal Produced in Assam, Meghalaya, Nagaland and Arunanchal Pradesh (Ash content not exceeding 25%)		
	------	342.0 ***

* Excludes Assam, Meghalaya, Nagaland and Arunachal Pradesh.

** When the Useful Heat Value(UHV) of non-coking coal exceeds 6400 kCal/kg, the price payable for Grade A shall be increased at the rate of Rs.1 for every 100 kCal by which the actual UHV exceeds 6400 kCal/kg. The pit-head prices are exclusive of royalty, cesses, taxes and levy, (if any, levied by the Govt., local authorities or other bodies) duties of excise and sales tax. The prices of steam coal and rubble are higher by Rs.7/tonne for each grade of non-coking coal; the prices of run-of-mine coal are lower by Rs.3/tonne for each grade.

*** In case of coal produced in the States of Assam, Meghalaya, Nagaland and Arunachal Pradesh, the price payable shall be increased at the rate of Rs.11/tonne, per percent of ash by which the ash content falls below 22%. Similarly, when ash content exceeds 25%, the price shall be reduced at the rate of Rs.11 per tonne per percent of ash by which the ash content exceeds 25%.

Source: Ministry of Energy, Department of Coal, Notification, New Delhi, 8th January 1986, The Gazette of India: Extraordinary, Part II-Section 3(ii).

Table IV.2.3: Price of Coking Coal

Grade *	Ash Content	Sale Price of Slack Coal ** (Rs/tonne)
S-I	= < 15%	485
S-II	= < 18%	405
W-I	= < 21%	350
W-II	= < 24%	292
W-III	= < 28%	225
W-IV	= < 35%	210
S/C-I	= < 19%	350
S/C-II	= < 24%	292

* S-I and S-II are steel grade prime coking coals. W-I, W-II, W-III and W-IV are medium coking coals that need to be prepared in washeries. S/C-I and S/C-II are semi or weakly coking coals. When the ash plus moisture content of semi-coking Grade I (S/C I) coals is less than 17%. the prices payable for S/C I shall be increased at the rate of Rs.5 for every 1% decrease in ash plus moisture content below 17%. The pit-head prices are exclusive of royalty, cesses, taxes and levy, if any, levied by Government, local authorities or other bodies, duties of excise and sales tax.

** Price of steam coal and rubble is higher by Rs.7/tonne for all grades of coking coal; and price of run-of-mine coal is lower by Rs.3/tonne for all grades.

Source : Ministry of Energy, op cit Ref. Table IV.2.2.

Table IV.2.4: Cost Parameters of Open Cast Coal Mining *

	Capital Cost (Rs/tpa)	Annual Operating Costs** (Rs/t)
a. Weighted Average	581	155
b. Max. Capital Cost	872	NA
c. Min. Capital Cost	204	NA
d. Max. Operating Cost	NA	222
e. Min. Operating Cost	NA	64

* Expressed in 1985 Prices.

** Assuming 100% capacity utilization.

a. Weighted average of 12 projects, using various technologies for opencast mining. All are however, mechanized. Mine capacity ranges from 1 mtpa to 14 mtpa. OMS ranges from 3.29 tonnes to 13.25 tonnes, with a weighted average of 9.96 tonnes.

b. For a mine of 12 mtpa capacity, 10.88 tonne OMS, 4.5 stripping ratio, and using 10 cu.m. rope shovels and 120 tonne rear dumpers for overburden removal.

c. For a mine of 10 mtpa capacity, 9.58 tonne OMS, 1.0 stripping ratio, and using 10 cu.m. rope shovels and 120 tonnes rear dumpers for overburden removal.

d. For a mine of 3 mtpa capacity, 8.71 tonne OMS, 5.13 stripping ratio and using draglines along with 10 cu.m. rope shovels and 120 tonne rear dumpers for overburden removal.

Source: Planning Commission, Draft Report of The Expert Group on Technology Options for the Coal Industry, May 1986.

Table IV.2.5: Cost Parameters of Underground Coal Mining *

	Capital Cost (Rs/tpa)	Annual Operating Costs ** (Rs/t)
a. Weighted Average	729	188
b. Max. Capital Cost	830	NA
c. Min. Capital Cost	262	NA
d. Max Operating Cost	NA	241
e. Min. Operating Cost	NA	92

* Expressed in 1985 prices.

** Assuming 100% capacity utilization.

a. Weighted average of 12 projects using various technologies for underground mining. Mine capacity ranges from 0.24 to 3.5 mtpa. OMS ranges from 0.39 tonnes to 4.26 tonnes with a weighted average of 2.75 tonnes.

b. For a mine of 2 mtpa capacity, 3.9 tonnes OMS and using the mechanized Longwall method of mining.

c. For a mine of 0.42 mtpa capacity, 1.2 tonnes OMS and using the mechanized Bord and Pillar Method.

d. For a mine of 0.3 mtpa capacity, 0.39 tonnes OMS and using the manual Bord and Pillar Method.

e. For a mine of 0.24 mtpa capacity, 2.4 tonnes OMS and using the Blasting Gallery method.

Source: op cit Ref. Table IV.2.4.

IV.3 Petroleum Pricing

Hydrocarbon pricing is very complex and prices are fixed by the Government from time to time, for various stages of the supply industry. The issue of pricing crude oil is complex because in addition to producing indigenous crudes from onshore and offshore fields, India also imports crude oils. Therefore, the crude oil prices paid to the petroleum exploration and development organizations are decided not only on the basis of costs incurred in the exploration and development, but also on the basis of international crude market conditions, and on the financial requirements for expanding exploration and production activities. The second stage of deciding prices paid by the refiners to procure indigenous and/or imported crudes, relates mainly to how the "economic rent" available from the use of an exhaustible resource, is to be shared between the producing and refining organizations. The third stage of fixing retention prices for refineries aims not only to provide an incentive for efficient refining operations, but also to rationalize the refinery output mix in line with the demand mix while ensuring the financial viability of refining companies. Likewise, retention prices for distributing and marketing agencies are fixed on the basis of certain efficiency norms of operations, including the use of common pipeline facilities. Finally, consumer prices are fixed on the basis of certain social considerations. These prices are administered through a series of pool accounts.

The weighted average of distribution costs for each product is incorporated in the price build-up, so that the price of a particular product is uniform all over the country. Any differences in consumer prices from one state to another, are due largely to differences in tax rates levied by the respective State Governments.

Although the weighted average of consumer prices has been maintained at parity or higher than border prices, cross-subsidization of products has posed certain problems. For instance, the subsidy on kerosene has made the production of soft-coke unprofitable. In addition, to reduce the adulteration of high speed diesel oils by kerosene, the Government has had little choice but to keep the price differentials between the two products low. However, this has resulted in a high price differential between petrol and diesel -- which has prompted several automobile owners to retrofit their vehicles with inefficient diesel engines. This pricing policy has therefore resulted in further increasing the demand for kerosene and high speed diesel oil, both of which are middle distillates and are imported at the margin.

Table IV.3.1: Prices of Indigenous Onshore and Offshore Crude Oils*
(Rs/tonne)

	With Effect From					
	July 14, 1975	Sept. 8, 1976	Dec. 16, 1977	April 16, 1981	July 11, 1981	Feb. 15, 1983
A. Onshore Crude Oils						
Base Price	195.04	230.41	203.41	203.41	1021	1021
Cess	60	60	60	60	100	300
Royalty	15	15	42	61	61	61
Total	270.04	305.41	305.41	324.41	1182	1382
B. Offshore Crude Oils						
Base Price			331.65	331.65	1021	1021
Cess			60	60	100	300
Royalty			42	61	61	61
Total			433.65	452.65	1182	1382

* The prices presented here are for crude oils of 34 °API gravity. They are subject to an escalation of Rs. 0.16/ °API, upto a maximum of 45 °API. No downward limit on the API gravity for a de-escalation in prices is specified. The prices are also inclusive of sales tax, which is the liability of the producer.

Source: Department of Petroleum, Indian Petroleum and Natural Gas Statistics, GOI, New Delhi, 1985-86.

Table IV.3.2: Retail Selling Prices of Selected Petroleum Products (in Bombay)

Prices as on	Mogas/Petrol * (Rs./litre)	HSD (Rs./litre)	Kerosene (Rs./litre)	LPG ** (Rs./Cylinder)
Jan 1,1971	1.16	0.79	0.54	NA
Jan 1,1972	1.42	0.83	0.57	NA
Jan 1,1973	1.43	0.83	0.61	NA
Jan 1,1974	2.81	0.81	0.82	20.01
Jan 1,1975	3.26	1.06	1.04	22.10
Jan 1,1976	3.36	1.28	1.21	26.75
Jan 1,1977	3.39	1.27	1.21	26.75
Jan 1,1978	3.38	1.27	1.18	26.75
Apr 1,1979	4.04	1.39	1.29	26.94
Aug 17,1979	4.43	1.58	1.46	33.96
Nov 11,1979	--	1.50	1.39	33.96
Jun 8,1980	5.15	2.21	1.39	33.96
Jan 13,1981	5.56	2.61	1.49	38.94
July 11,1981	6.15	2.96	1.60	43.52
Apr 1,1982	6.15	2.96	1.66	43.52
Feb 15,1983	6.21	3.21	1.70	43.14
Apr 1,1983	6.21	3.21	1.80	43.14
Apr 1,1984	6.32	3.21	1.81	43.14
Jun 1,1984	6.41	3.27	1.85	44.11
Apr 1,1985	7.34	3.45	2.03	49.95
Apr 1,1986	7.79	3.57	2.17	56.15

* Price for Mogas 83 until April 1, 1983; Price for Mogas 87 thereafter.

** Price for a 15 kg cylinder until Jan 1, 1975; Price for a 14.2 kg cylinder thereafter.

Source: Department of Petroleum, op cit Ref. Table IV.3.1.

IV.4 Electricity Pricing

The basis for setting electricity prices can be very different from coal or petroleum prices, even if only because electric power cannot be usually stored; which means that the cost of meeting power requirements vary with the time of day. Therefore, it is clear that the power tariff during peaking hours must be higher than during off-peak hours -- at least for major electricity consumers. This practice however, has not been adopted in India so far. One of the reasons is that appropriate meters are not available -- which can record the electricity consumption during peaking hours separately.

In fact, the electricity tariffs in India are usually below the costs of power generation and supply. As a result, the electric utilities in India have generally found it difficult to expand their generating capacity (to keep pace with rising demand) and to modernize their facilities. The problem is compounded further when due to lack of adequate financial resources, project implementation slows down, thus leading to substantial cost over-runs, and a further rise in supply costs. At the same time, strengthening and expanding the transmission grid is not given adequate consideration, as investment allocated for transmission projects gets reallocated for generation schemes. Moreover, as the rural electrification programme has continued to expand, an increasing share of elctricity is consumed in the agriculture sector -- which has the lowest tariff although the costs of power supply to it are probably the highest.

Table IV.4.1: Electricity Tariffs (All India Average)
(paise/kWh)

1970/71	12.44
1972/73	14.15
1974/75	18.39
1976/77	23.79
1978/79	28.99
1979/80	31.28
1980/81	33.23
1981/82	38.76
1982/83	43.45
1983/84	51.55
1986/87	61.09

Source: CEA.

Table IV.4.2: Cost of Generation and Supply of Electricty (paise/kWh)

	Generation Cost(1984/85) Thermal	Hydro	Ave. Cost of Supply in 1986/87	Ave. Tariff in 1986/87
Andhra Pradesh	38.1	5.33	54.15	50.3
Assam	NA	NA	187.29	56.57
Bihar	58.16	16.75	132.79	78.98
Gujarat	40.26	9.13	85.11	77.15
Haryana	82.34	7.90	73.71	42.70
Himachal Pradesh *	--	8.05	85.49	49.00
Jammu & Kashmir	NA	NA	82.08	29.97
Karnataka *	--	20.04	67.27	54.91
Kerala *	--	6.1	44.86	39.78
Madhya Pradesh	35.25	6.33	71.17	67.03
Maharashtra	43.10	4.80	70.53	68.37
Meghalaya	NA	NA	97.31	47.20
Orissa	39.68	7.58	51.58	52.21
Punjab	53.16	7.99	71.02	42.23
Rajasthan	48.52	9.01	79.03	63.75
Tamil Nadu	61.10	7.37	75.47	55.67
Uttar Pradesh	67.37	15.99	87.25	66.83
West Bengal	43.92	37.27	98.96	79.53

* There are no thermal power stations.

Source: Centre For Monitoring Indian Economy, Current Energy Scene in India, May 1987, Bombay.

V. TECHNOLOGY DEVELOPMENT

V.1 Introduction

The supply and demand scenario for the so-called "conventional" energy forms is presented in the preceding sections. However, with technological development, it becomes possible to: (i) harness certain renewable energy sources, such as solar and wind, as also hydroelectric potential from low heads; and (ii) improve the utilization efficiency of certain fuels that are already used, such as firewood, crop residues and animal wastes.

The Government's priorities for promoting various renewable energy technologies (RETs) certainly reflect the level of maturity that a particular technology has attained until now. While large scale dissemination has already begun for some relatively mature technologies such as improved chulhas, biogas plants, solar cookers and solar water heating systems, other technologies are still at the demonstration or pilot field testing stage. However, it is essential that all renewable energy technologies and devices used in rural and urban areas must hold promise of providing net benefits to society--albeit in the long run. Present day cost competitiveness vis-a-vis conventional technologies need not be the sole criterion, particularly if recent trends in technological innovation and cost reduction are encouraging.

That financial incentives are required for promoting RETs is recognized by the Government. In India, such incentives have largely been in the form of a direct subsidy (from the central Government) or in the form of soft loans and sales tax exemptions (as offered by the Governments of certain states and union territories). Such financial incentives are still confined largely to those beneficiaries who install and use biogas plants, improved chulhas, solar cookers and other solar thermal devices, and at least in some states, wind mill pumps. As the PV and the wind electric programmes are still at the field testing stage, or in the initial stages of a demonstration programme, the capital and operating costs as well as other expenses are borne entirely by the Department of Non-Convetional Energy Sources (DNES), or other Government agencies in the state.

V.2 Solar Thermal Technologies

The technical viability of solar hot water technology and solar cookers has been established through demonstration projects. New devices like solar timber kilns, solar air heaters, solar crop dryers, solar desalination systems and solar domestic hot water systems have also been included in the extension programme after successful field trials under the demonstration programme.

Due largely to the rather generous subsidy offered by the DNES to users of solar thermal devices (and also owing to additional subsidies granted by the respective state governments), the market for solar thermal devices grew rapidly in 1984/85. In 1984/85 alone, the DNES' budgetary allocation for dissemination of solar thermal devices was about Rs.50 million. However, as only Rs. 170 million are committed for the entire Seventh FYP period, the market for solar thermal systems seems to have dried up suddenly. This has affected the operations of several manufacturers considerably.

Solar cookers are perhaps the most popular solar thermal devices. The DNES pays a central subsidy of 33.3% of the cost or Rs.150, which ever is less, to users who purchase solar cookers. In addition, some states extend a further subsidy of Rs.100 to Rs.200. Over 72,000 solar cookers have now been disseminated.

The DNES is also supporting a sizeable R & D programme to develop solar technologies for medium and high temperature applications.

Table V.2.1: Solar Thermal Devices - No. of Installations (As on January 15, 1987)

	Until March 31, 1985	Additions in 1985/86	Additions from April 1, 1986 to Jan 15, 1987	Until Jan 15, 1987
a. Solar Water Heating Systems	182	343	479	1004
b. Solar crop dryers/ air heating systems	12	11	5917	5940
c. Solar timber kilns	12	8	14	34
d. Solar desalination systems	28	112	5800	5940
e. Domestic Solar Water Heaters	200	100	866	1166
f. Total	434	574	13076	14084

Source: Ministry of Energy, Department of Non-Conventional Energy Sources, Annual Report, various issues.

Table V.2.2: Solar Thermal Devices-Statement of Achievement of the Demonstration/Extension Programme (As on Jan 15, 1987)

	Solar Water Heating Systems*			No. of Air Heaters/ Crop Dryers	No. of Solar Timber Kilns	No. of Solar Stills
	No. of Installations	Capacity (litres/day)	Collector Area(m2)			
Andhra Pradesh	21	96000	1920	1	4	2
Arunachal Pradesh	-	-	-	-	1	-
Assam	8	2000	40	3	-	-
Bihar	1	4000	80	-	-	-
Delhi	93	295650	5913	1	2	1604
Gujarat	262	555580	11172	5	7	3163
Haryana	29	68800	1386	-	1	-
Himachal Pradesh	21	12600	260	-	2	-
Jammu & Kashmir	5	19000	380	-	-	28
Karnataka	21	26650	576	1	1	-
Kerala	16	13300	266	1	-	4
Maharashtra	18	58800	1235	-	-	25
Madhya Pradesh	109	339850	8098	1	1	273
Orissa	30	4220	758	-	-	80
Punjab	61	127900	2558	1	2	40
Rajasthan	39	15750	315	-	-	-
Tamil Nadu	50	275100	5502	1	-	-
Uttar Pradesh	202	170100	3400	12	12	111
West Bengal	-	-	-	1	1	-
All States	986	2085300	43859	28	34	5330

* Excludes Domestic Solar Water Heaters.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

V.3 Solar Photovoltaics

Photovoltaic (PV) systems are modular in nature and can be used to meet electrical energy requirements for a variety of applications. PV systems are relatively easy to install and maintain. They cause no noise or other pollution, and have a long life; and are therefore suited for use in remote and isolated areas and in villages which are not served by conventional electricity grids.

During 1986 and 1987, the DNES pursued a wide variety of projects for development, production and application of solar PV devices. The DNES also launched a "Science and Technology Project" for the development of amorphous silicon which is to be implemented on a top priority basis during the Seventh FYP period. This project has three main elements : (i) to intensify and accelerate the R&D effort; (ii) to establish a pilot plant with a capacity of manufacturing 500 kWp modules per annum on a single shift basis; and (iii) to develop and evaluate systems compatible with amorphous silicon modules.

During 1985/86, the bulk of the photovoltaic systems were manufactured in BHEL and CEL. A third organization, the Rajasthan Electronics and Instruments Ltd. (REIL) at Jaipur, began production of modules, and systems in late 1985/86.

The demonstration programme has progressed satisfactorily. In addition to water pumping, street lighting and community lighting/TV systems, battery charging units and central PV stations already installed, signalling and communication systems for the railways are also being established.

Table V.3.1: Photovoltaic Demonstration Programme: Targets and Achievements

	Targets for 1986/87	Systems supplied upto December 31, 1986.
Water Pumping Systems	350	229
Street Lighting Systems	3000	3060
Community Lighting/T.V. Systems	45	18
Battery Charging Units	300	308
PV Power Plants	100 kWp	27 kWp

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table.V.3.2: Photovoltaic Systems -- Status of the Demonstration Programme

Application	Status/Achievements
1. Pumping	**1985/86:** As recommended by the Advisory Board on Energy, 100 pumps were installed in six States(Andhra Pradesh, Bihar, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal). In addition, 46 systems were also supplied to various states for the purpose of demonstration. A programme for setting up another 300 demonstration units is being implemented.
	1986/87: As many as 229 pumps were supplied between April and December 1986. A project for the installation of 10 photovoltaic powered deepwell pumping systems is being taken up with assistance from the Danish Government.
2. Community T.V./Lighting	**1985/86:** 200 PV powered TV sets were installed in Uttar Pradesh and Bihar.
	1986/87: 18 community lighting/TV systems had been supplied upto Dec.1986. Additional TV and community lighting systems are planned for Gujarat, Madhya Pradesh, Orissa and Lakshadweep.
3. Village Electric-fication	**1985/86:** Programme to have PV powered street lights in 250 villages was initiated.
	1986/87: Over 3000 street lighting units have been supplied between April and Dec. 1986. It is anticipated that a total of over 4000 units will be supplied before March 31, 1987, which would be adequate to cover more than 400 villages against a target of 300 villages.
4. Centralized PV Systems	**1985/86:** In 4 villages "centralized" PV powered systems for meeting street lighting and other electrical energy requirements were set up. Moreover, the DNES also proposed to set up 4 PV power stations, each in the capacity range of 10-20 kW.
	1986/87: A 20 kW plant has been approved for installation at Rai in Haryana. A 24.5 kWp photovoltaic system with a diesel back up has been sanctioned for Similipal National Park in Orissa. The third project envisages the integration of a 15 kWp photovoltaic power system with a 50 kW wind generating system near Okha in Gujarat. A 5 KW power plant has been approved for installation in Lakshadweep Islands.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

V.4 Wind Energy Programme

During the first two years of the Seventh FYP period, the wind energy programme has expanded significantly. The wind pump demonstration/field trials programme has been extended to include private farmers also. Five wind farm projects have been completed; nearly 6 GWh of grid quality electricity has already been fed to the respective state grids from the wind farms installed in coastal areas of the country.

The data base on wind regimes however, leaves much to be desired. Until now, wind data have been gathered from the meteorological point of view, and not with the objective of assessing the wind potential. The major shortcomings are: (i) the anemometer and anemograph stations may be obstructed by buldings or trees; (ii) wind speeds are usually recorded at a height of 5 to 15 metres; (iii) the number of wind measurement stations is very less; and (iv) regions experiencing very strong winds may not have wind measuring stations. The DNES therefore, has initiated a programme for strengthening the wind energy data base.

Although wind speed data at a height of 6 to 15 metres may suffice for evaluating water pumping wind mills, they will be inadequate for assessing the potential for wind electric generators (WEGs). WEGs are usually installed at a height of 20 to 35 metres; the height being related to the dimensions of the rotor, which in turn reflects the rating of the WEG.

Although wind electric generation shows promise, and the wind electric programme has been largely successful so far, certain problems still remain. The grid connected WEGs generate within a certain tolerance range of voltage and frequency in the grid. The WEG switches off and the rotor is braked in case of any fluctuation beyond this range. As utility grids in the coastal areas in India are usually not very strong, they are subject to frequency,and large fluctuations in voltage and frequency, which not only increases the downtime of WEGs, but also reduces equipment life.

In addition to the demonstration programme, research and development activities of the DNES are oriented towards improving designs of wind pumping systems suitable for various wind regimes and ground water depths. The design, testing and adaptation of wind electric systems, particularly for battery charging, have also been taken up.

Table V.4.1: Stations with Annual Mean Windspeed Over 13km/hour

Station	Wind Speed (km/hr)	Period of measurement
Alibag	14.1	1958-67
Amini Divi	14.1	1963-69
Bhavnagar	18.0	1958-67
Bhuj	13.3	"
Bidar	13.3	"
Coimbatore airport	18.1	"
Dhanu	14.9	"
Devgarh	16.6	"
Dohad	14.6	"
Dwarka	17.3	"
Gopalpur	14.5	"
Harnai	15.4	"
Indore	14.4	"
Jaisalmer	13.0	"
Jalgaon	13.5	"
Kandla airport	20.7	1961-69
Kanya Kumari	17.7	1961-67
Keshod airport	17.5	1958-67
Kodaikanal	13.2	"
Mahabaleshwar	13.1	"
Mandavi	22.8	"
Nagapattnam	13.9	"
Naliya	13.5	"
Okha	20.6	1963-69
Pamban	14.5	1958-67
Phalodi	13.3	"
Porbandar	15.5	"
Puri	16.3	1960-69
Rajkot	18.6	1958-67
Sagar Island	19.6	"
Tiruchchirappalli	13.7	"
Tondi	15.4	"
Tuticorin	16.8	"
Veraval	19.5	"

Source: Anna Mani and D.A. Mooley, Wind Energy Data for India, Allied Publications, 1983.

Table V.4.2.: Status of the Windpumping Demonstration Programme. (As on December 31, 1986)

	No. of wind-pumps installed until March 31, 1986	Additions between April 1, 1986 and December 31, 1986	Total no. installed until December 31, 1986.
Andhra Pradesh	176	50	226
Bihar	74	53	127
Delhi	30	15	45
Gujarat	94	-	94
Haryana	30	-	30
Himachal Pradesh	9	-	9
Jammu & Kashmir	2	1	3
Karnataka	17	-	17
Kerala	4	-	4
Madhya Pradesh	164	-	164
Maharashtra	111	11	132
Nagaland	4	-	4
Orissa	156	46	202
Punjab	77	-	77
Rajasthan	76	-	76
Tamil Nadu	83	110	193
Uttar Pradesh	198	54	252
West Bengal	11	4	15
Tripura	2	-	2
Union Terriotries			
Andaman & Nicobar Island	14	-	14
Chandigarh	4	-	4
Goa	6	-	6
Pondicherry	10	-	10

Source: Ministry of Energy , op cit Ref. Table V.2.1.

Table V.4.3: Indigenously Designed Windpumping Systems*

Manufacturer	Salient Design Features
Indoxy	Vertical axis windmill`S' type rotor, diaphragm pump.
Pooja	Horizontal axis windmill, APOLLY Design.
Surya Shakti	Horizontal axis windmill, 1.5 metre plastic rotor, 6 metre tower, special piston pump.
BHEL	Horizontal axis windmill, multivane, 10 cm diametre brass liner pump.
BHEL	Horizontal axis windmill, modified and strengthened for cyclone prone areas.
BHEL	Horizontal axis windmill with provision for manual operation during non-windy periods.
Samira	---
LGB	---

* Under Field Testing.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table V.4.4: Windfarm Demonstration Projects *

Location	Aggregate Capacity (kW)	Unit Size (kW)	Manufacturer
Mandavi (Gujarat)	1159	2 x 10	Micon
		14 x 55	Micon
		6 x 22	Windane
		2 x 18.5	Windane
Tuticorin (Tamil Nadu)	550	14 x 55	Windmatic
Okha (Gujarat)	550	10 x 55	Vestas
Puri (Orissa)	550	10 x 55	Vestas
Devgarh (Maharashtra)	550	10 x 55	Vestas

* All were installed during 1986. Substantial expansion under way.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table V.4.5: Comparative Wind Farm Performance--
Month Wise Generation (GWh)

Month Wise Generation	Mandavi	Tuticorin	Okha	Puri	Devgarh
1986					
January	14760	42345	-	-	-
February	57958	53271	-	-	-
March	77777	54285	66210	-	-
April	168700	30855	101540	-	-
May	238980	40159	166830	55258	43540
June	213500	105387	107590	62212	102640
July	347340	137493	130940	14956	58940
August	280390	96333	112007	32016	69410
September	168580	90254	43673	19793	12960
October	91780	24621	25880	5992	6720
November	35780	39092	31140	2728	10840
December	41200	85737	79400	8432	28964
1987					
January	34600	109876	65990	9902	14500
February	43380	62309	39710	8604	29520
March	76100	53666	48800	63467	27560
April	160640	41115	80110	55468	35240
May	191600	40384	94410	70661	37460
June	233100	120356	-	46484	73960
Total (until June 1987)	2476165	1227538	1194230	455973	552254

Source: DNES.

V.5 Biogas Programme

Biogas is an important renewable source of energy and may be produced from organic materials like cattle dung, human wastes and different types of biomass. It provides a clean and smokeless fuel for domestic cooking, and the biogas plant also produces enriched and high quality organic fertilizer. The biogas programme has become increasingly popular in rural areas all over the country.

The National Project on Biogas Development (NPBD) for the promotion of family size biogas plants, was initiated in 1981/82. Over 540,000 family size plants were installed until 1985/86; of which, nearly 200,000 were installed during 1985/86 alone. Some steps have also been taken since 1984/85, to improve the performance of family size plants. These measures include technical improvements in the design, training support, repair and maintenance facilities and regular monitoring and evaluation. The users however, still continue to be subsidized; which indicates that further R & D inputs may be necessary before the techno-economic viability of the technology is firmly established.

In addition, the Government has also initiated a demonstration programme to familiarize users with community size biogas plants. It is an integrated decentralized waste recycling and energy generation system, for providing rural needs for cooking, water pumping and sanitation. In order to extend this facility to more villages, the subsidy pattern was modified, beginning November 1986: (i) for community biogas plants (CBPs), the central assistance was reduced to 90% from 100% ; and (ii) for institutional biogas plants (IBPs), the central financial assistance was reduced from 75% to 70%.

Although the biogas production technology has become popular throughout India, the R & D programme is still being pursued vigorously. Some projects aim to develop more economical designs of digestors, burners and biogas engines. Other projects are to develop designs for using water-hyacinth and aquatic biomass as feedstock. Still others are to develop digestors in which food processing wastes, pulp and water mill wastes, and a variety of industrial effluents can be used as feedstock. Simultaneously, microbiological studies are in progress, in which the enhancement of biogas production through selective microbial action is being studied.

Table V.5.1: Progress of National Project on Biogas Development During 1986/87

State/U.T.	Target	Achievement
A. States		
Andhra Pradesh	20000	17181
Assam	1000	731
Bihar	6400	9142
Gujarat*	5000	9811
Haryana	2200	2479
Himachal Pradesh	2500	2850
Jammu & Kashmir	120	116
Karnataka	7000	7007
Kerala	2400	2072
Madhya Pradesh	3000	3074
Maharashtra	44000	58057
Manipur	25	-
Meghalaya	30	-
Nagaland	10	-
Orissa	2500	4310
Punjab	1600	1445
Rajasthan*	5000	4321
Sikkim	5	25
Tamil Nadu	13120	19335
Tripura	10	-
Uttar Pradesh	20000	27418
West Bengal*	2800	6207
B. Union Territories		
Andaman & Nicobar	5	40
Chandigarh	5	5
Dadar & Nagar Haveli	10	15
Delhi	60	110
Mizoram	150	152
Goa, Daman & Diu	100	115
Pondicherry	100	30
C. KVIC*	15000	21013
D. TOTAL	150150	198061

* The revised targets for Gujarat, Orissa, Rajasthan, West Bengal and KVIC were 8000, 4000, 5600 and 1800 respectively.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table V.5.2: Summary of Findings of Biogas Plant Evaluation Survey Studies*

State	Sample Size		% Plants Working		% Plants With Structural Defects		% Plants With Non-Structural Defects	
	No. of Plants	% of total	NPBD**	Pre-NPBD	NPBD	Pre-NPBD	NPBD	Pre-NPBD
a. Surveyed by National Council of Applied Economic Research, New Delhi.								
- Bihar	1087	4.7	82.1	69.3	2.6	4.4	15.3	26.3
- Uttar Pradesh	2652	3.9	77.0	72.4	5.2	3.8	17.8	23.8
- Madhya Pradesh	775	5.2	64.3	64.9	4.2	3.0	31.5	32.1
- Andhra Pradesh	792	5.5	93.6	79.7	4.6	1.3	1.8	19.0
b. Surveyed by Kirloskar Consultants Limited., Pune.								
- Haryana	1425	9.4	79.4	52.6	7.6	31.9	13.0	15.5
- Punjab	825	9.6	96.6	89.3	1.7	5.6	1.7	4.9
- Himachal Pradesh	125	5.7	100.0	100.0	Nil	Nil	Nil	Nil
c. Surveyed by Operations Research Group, Baroda.								
- Karnataka	710	3.7	86.1	82.9	6.6	11.4	7.3	5.7
- Maharashtra	1347	2.8	93.0	84.8	5.4	14.4	1.6	0.8
d. Surveyed by Besant Raj Consultants (P) Ltd., Madras.								
- Tamil Nadu	1340	6.6	88.1	81.1	6.5	6.7	5.4	12.2
- Kerala	400	11.4	95.7	76.7	3.3	8.1	1.0	15.2
- Orissa	405	11.2	93.9	81.5	2.2	10.8	3.9	7.7

* For biogas plants installed until 1983/84.
** NPBD programme was initiated in 1981/82.

Table V.5.3: Pattern of Central Subsidy for NPBD Plants (Rupees)

Capacity of Plant (cu.m. of gas/day)	For North Eastern Region States*	Scheduled Castes, Scheduled Tribes, Small & Marginal Farmers Including Landless Labourers	For All Others
1	1500	1250	830
2	2940	2350	1560
3	3660	2860	1900
4	4390	3220	2140
6	5350	3920	2610
8	6460	3100	3100
10	8080	3700	3700
15	11440	5430	5430
20	15260	7300	7300
25	17640	8190	8190

* Includes Sikkim and notified Hilly Areas and Desert Districts.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table V.5.4: Achievements of Completed CBP/IBPs

	Upto March 31, 1985		1985/86		1986/87*	
	CBP	IBP	CBP	IBP	CBP	IBP
Andhra Pradesh	10	5	7	9	1	-
Assam	-	1	-	-	-	-
Bihar	-	-	-	-	2	-
Delhi	1	-	-	-	-	-
Gujarat	6	1	6	1	3	1
Haryana	-	3	2	-	-	1
Himachal Pradesh	-	1	-	-	-	-
Karnataka	2	-	-	-	-	-
Kerala	-	2	-	-	-	-
Madhya Pradesh	2	12	10	3	1	1
Maharashtra	2	6	-	1	-	11
Orissa	1	-	2	1	1	3
Pondicherry	-	1	-	-	-	-
Punjab	7	2	5	-	2	15
Rajasthan	4	10	1	6	-	1
Tamil Nadu	2	1	-	-	-	-
Uttar Pradesh	9	9	15	3	7	3
West Bengal	1	-	1	-	-	-
Total	47	54	48	24	17	36

* As on December 31, 1986.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

V.6 Improved Chulhas

The main objectives of the national programme on improved chulhas, which was launched by the DNES on April 1, 1985, are: (i) to conserve and optimize the use of fuelwood to reduce deforestaion and to alleviate the drudgery of women in rural areas; (ii) to create a work-force of trained persons who are competent to construct/install improved models of chulhas, thereby generating employment in rural area; (iii) to introduce training programmes for training master craftpersons in the construction of improved chulhas; and (iv) to accelerate technical and R & D activities so as to bring better models on the list approved for propagation.

There are two major types of chulhas which are being disseminated: (i) fixed model chulhas, made of clay, brick etc.; and (ii) portable models, made of steel. A model which satisfies the following criteria only is considered for propagation under the national programme: (i) its thermal efficiency should be at least 20% (compared to traditional models whose efficiency usually ranges from 2 to 10%); (ii) it should be cheap and easy to construct; and (iii) it should be acceptable to the user.

The approved models are still subsidized by the DNES. Along with fuel savings, a need has been felt to study the pollutant emissions of the improved chulhas. Extensive studies on pollutant emissions and their health effects on rural women (who cook) and their effects on the surrounding environment have been conducted.

Table V.6.1: Number of Improved Chulhas Installed During 1986/87

State/U.T.	No. of Chulhas Installed
Andhra Pradesh	125761
Assam	2070
Bihar	49750
Gujarat	52322
Haryana	64731
Himachal Pradesh	50443
Jammu & Kashmir	12213
Karnataka	46991
Kerala	1368
Madhya Pradesh	50258
Maharashtra	44881
Manipur	280
Meghalaya	1500
Orissa	34239
Pondicherry	1175
Punjab	43150
Rajasthan	73745
Sikkim	2030
Tamil Nadu	85777
Uttar Pradesh	102465
West Bengal	38326
Dadra & Nagar Haveli	500
Delhi	9495
Goa	5050
Others	6467

Source: Ministry of Energy, op cit Ref. Table V.2.1.

Table V.6.2: Pattern of Subsidy For Improved Chulhas*

	Subsidy for Scheduled Tribes, Scheduled Castes and Hilly Areas	Subsidy for Other Areas
Fixed model of chulha	Full cost of hardware (Chimney, dampers etc.)	Full cost of hardware (Chimney, dampers etc.)
Portable model of chulha	75% of the approved cost of a model	50% of the approved cost of a model

* In addition a supervisory fee of Rs.5/- is paid to the trained worker on the construction/installation of each stove.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

V.7 Small Hydropower Stations

Until the recent past, small hydro power was the most unappreciated and most neglected energy resource, although it has been known for over a century. The small hydro potential in the country is estimated at about 5000 MW comprising: (i) 2000 MW potential with small discharges and high heads, as in hilly areas; and (ii) 3000 MW potential with large discharges under comparatively low heads, as on small rivers, irrigation outlets, canal falls etc.

One of the major disadvantages of small hydro projects is stated to be the high capital cost. This is particularly true for projects which are constructed in remote and hilly areas, where infrastructural facilities are limited. The DNES has therefore undertaken a research, development and demonstration programme of small hydro projects. Four demonstration projects are now in various stages of completion.

Table V.7.1: Small Hydro Demonstration Programme

Location	Capacity (kW)	Net head (metres)	Design Discharge (cusecs)	Remarks
Jubbal (Himachal Pradesh)	1 X 100 (Synchronous) +2 X 25 (Induction)	88	0.17	Commissioned in June, 1985; High head.
Manali (Himachal Pradesh)	1 X 100 (Synchronous) +1 X 100 (Induction)	40	0.8	Commissioned in June, 1985; medium head.
Sonepat - I (Haryana)	1 X 100 (Synchronous) +1 X 100 (Induction) +1 X 100 (synchronous)	1.9	31.15	Expected to be Commissioned in 1987/88; ultra low head.
Bhatinda (Punjab)	1 X 100	3	8.5	Expected to be Commissioned in 1988/89; low head.

Source: Ministry of Energy, op cit Ref. Table V.2.1.

VI. ENVIRONMENTAL IMPLICATIONS OF ENERGY USE

VI.1 Enviromental Effects of Energy Use

Until recently, energy planning in India was done with little concern for environmental effects of energy production, conversion, transportation and utilization. However, the implications of one or more of these steps in the energy chain may be particularly severe in areas of concentrated population and/or activity. Metropolitan cities, industrial townships and villages around large mining centres are some such areas.

Among the environmental effects that may be considered, is the impact of pollutant emissions on human health and ecology. Although it is difficult to relate such impacts to exposure times and concentration levels of various pollutants, some indicative information presented in Tables VI.1.1 through VI.1.3 highlights this important issue.

Tables VI.1.4 through VI.1.7. also show that pollutant emissions and other environmental implications are indeed associated with energy utilization. It has been observed that the very process of coal extraction leads to siltation, soil erosion, coal dust in air, and so on. Some of these issues may not be of immediate consequence, but are important nevertheless from a long term point of view. Likewise, coal transportation/processing, combustion and ash disposal are also known to contribute to enviromental pollution.

Similar impacts may be observed with the utilization of petroleum products and traditional fuels as well. Burning fossil fuels and biomass-based fuels introduces large quantities of carbon-dioxide into the atmosphere. Although carbon-dioxide is not formally classified as a pollutant, it can introduce climatic changes in the long run (e.g. rising temperatures), if its concentration levels in the atmosphere keep increasing. Such changes may have severe consequences for tropical countries; because they may be highly unpredictable, uncontrollable and perhaps irreversible -- and should be a major concern in India, where forests (which fix atmospheric carbon dioxide) are depleting at an alarming rate.

Besides carbon-dioxide, the use of hydrocarbon fuels also results in the emission of carbon-monoxide, unburned hydrocarbons, nitrogen oxides and particulates. Exhausts from transport vehicles include all these pollutants; a fact which is of relevance to major cities and towns in India. In particular, as the number of 2/3 wheelers has increased rapidly during the last decade (and is likely to continue in to the foreseable future), special emphasis should be placed on a programme to limit the emission of unburned hydrocarbons, as also of carbon-monoxide.

Pollutant emissions from various types of cooking stoves using fuelwood, crop residues, cowdung cakes, or even coal and kerosene, can be considerable. This is of particular concern to developing countries like India, where evidence is now beginning to accumulate, indicating that a large number of people who are exposed to significant air pollutants generated from open combustion of biomass, may be at a relatively higher risk of contracting several diseases.

Table VI.1.1: Observed Effects of Particulates

Concentration (mg/cu.m.)	Measurement Conditions	Effect
60-180	Annual geometric mean with moisture	Acceleration of corrosion of steel and zinc panels.
75	Annual mean	USEPA 1974 air quality standard.
150	Relative humidity less than 70%	Visibility reduced to 8 Km.
100-150	-	Direct sunlight reduced to one-third.
80-100	With Sulphation levels of 30 mg/cm2/month	May increase death rate of persons over 50.
100-130	With $SO_2>4120$ µg/cu.m.	Childern likely to experience increased incidence of respiratory disease.
200	24-hour average and $SO_2>250$ µg/cu.m.	Illness of industrial workers may increase absenteeism.
260	Maximum Once in 24 hrs	USEPA 1974 air quality standard.
300	24 hr maximum and $SO_2)$ 630 µg/cu.m.	Symptoms of chronic bronchitis patients are likely to worsen.
750	24 hr average and $SO_2>715$ µg/cu.m.	Excessive no. of deaths and considerable increase in illness may occur.

Source: National Air Pollution Control Association, "Air Quality Criteria for Particulate Matter, AP-49, Washington, D.C., HEW, 1969.

Table VI.1.2 : Health Effects of Carbon Monoxide (CO) and Carboxyhaemoglobin (COHb)

Concentration	Exposure	Effects
CO (ppm)		
9	-	USEPA ambient air quality standard.
50	6 weeks	Structural changes in heart and brain of animals.
50	50 minutes	Changes in relative brightness and visual activity.
50	8-12 hours	Impaired performance on psychomotor tests in non-smokers.
COHb Level (%)		
< 1		No apparent effect.
1-2		Some evidence of effect on behavioral performance.
2-5		Central nervous system effects- Impairment of time-interval discrimination, visual activity brightness discrimination, and certain other psychomotor functions.
> 5		Cardiac and pulmonary functional changes.
10-80		Headaches, fatigue, drowsiness, coma, respiratory failure, death.

Source : Wark, K. and Warner, C.F. "Air Pollution : Its Origin and Control", Harper and Row, New York, 1976.

Table VI.1.3. : Effects of SO_2 at Various Concentrations

Concentration (ppm)	Duration	Effects
0.03	annual	USEPA 1974 air quality standard, chronic injury.
0.037-0.092	annual	Accompanied by Smoke at 185 µg/cu.m., increased frequency of respiratory symptoms and lung diseases.
0.11-0.19	24 hour	With low particulate level, rise in hospital admissions of elderly for respiratory symptoms, increased metal corrosion.
0.19	24 hour	With low particulate level, increased mortality may occur.
0.25	24 hour	Accompanied by smoke at a concentration of 750 µg/cu.m., increased daily deaths may occur (U.K. data).
0.3	8 hour	Some trees show injury.
0.52	24 hour	When accompanied by particulates, increased mortality may occur.

Source : National Air Pollution Control Administration, "Air Quality Criteria - for Sulphur Oxides", AP-50, Washington, D.C., HEW, 1970.

Table VI.1.4. : Environmental Impacts Associated with the Different Stages Of The Coal Life Cycle

Stages	Impacts mediated through		
	Air	Land	Water
1. Extraction	Coal dust, (surface mines), occupational hazards	Disturbed Land, Soil erosion	Chemical mine drainage, siltatation
2. Transport & Processing	Coal dust, Noise, Diesel exhaust	Land requirements	Only for slurry pipelines
3. Combustion	Particulates (Trace Elements, Radionuclides, polycyclic organic matter) and gases (SOx, NOx, COx)	Combustion Products; Fallout including Acid Rain. Reduction in plant productivity	Thermal discharge, Combustion Products, Fallout including Acid Rain, Reduction in aquatic prodctivity
4. Ash Disposal		Land requirements	Possibility of leachates (especially toxic trace metals & radionuclides)

Source : Dilip R. Ahuja and J.D. Pandya, "Power Industry", in P.L. Diwakar Rao (ed.), Pollution Control Handbook, Utility Publications Ltd., Secundrabad, 1986.

Table VI.1.5. : Urban Air Pollution From Vehicular Emissions

Emissions	Source of Emission	Contribution of the Source in total Emissions	Remarks
1. Carbon monoxide (CO)	Petrol driven vehicles	85%	Contribution of two wheelers is expected to rise.
2. Unburned Hydro-carbons	Two and Three Wheelers	35-65%	Contribution of two and three wheelers expected to increase to 80% by 1991-92.
3. Nitrogen Oxides (NO_x)	Diesel driven vehicles	> 90%	-
4. Particulates	Diesel driven vehicles	-	-

Source : B. Bowonder, "Air Pollution" in P.L. Diwakar Rao (ed.), op cit Ref. Table VI.1.4.

Table VI.1.6. : Emission Factors For Different Pollutants From Cooking Stoves For Various Fuel-Stove Combinations (g/kg)

Stove Type Fuel and Pollutant	Conventional Metal **	Improved Metal **	Improved Mud **
Fuel Wood			
TSP	1.3 - 2.7	1.1 - 3.8	1.8 - 2.1
CO	13 - 22	25 - 62	32 - 48
Crop Residues			
TSP	2.1 - 5.0	2.1 - 12.0	3.5
CO	20 - 39	23 - 114	48
Dung Cakes			
TSP	4.1 - 5.3	4.2 - 7.8	7.4
CO	11 - 16	34 - 67	46

* Two port; with flue (1.5 - 1.8 metres), vented inside.
** One port.

Source: TERI, Evaluation of Performance of Cookstoves In Regard to Thermal Efficiency and Emissions from Combustion, submitted to Ministry of Environment, Forests and Wildlife, Government of India, Feb. 1987.

Table VI.1.7: Smoke Exposures and Concentrations Due to Traditional and Improved Cookstoves with Flues*

Location	Pollutant	Traditional Stoves No. of expts	Traditional Stoves Mean	Improved Stoves No. of expts	Improved Stoves Mean
<u>Personal monitoring</u>					
Nepal a. Two mid-hill villages	TSP	22	3.1 mg/cu.m.	27	1.1 mg/cu.m.
India b. Two Gujarat villages	TSP	21	6.4 mg/cu.m.	14	4.6 mg/cu.m.
	BAP	21	3.7 μg/cu.m.	14	2.4 μg/cu.m.
c. Eight Gujarat villages (3 stoves)	TSP	45	4.4 mg/cu.m.	57	4.0 mg/cu.m.
One stove type (4 villages)	TSP	21	3.6 mg/cu.m.	23	3.9 mg/cu.m.
d. One Haryana village(f)	TSP	51	3.2 mg/cu.m.	36	2.8 mg/cu.m.
d. Two Karnataka villages (f,g)	TSP	39	3.5 mg/cu.m.	40	2.6 mg/cu.m.
<u>Area monitoring</u> (since placement is so critical, comparisons should be done within and not between different studies)					
a. Nepal Two mid-hill villages	CO	27	300 ppm	26	67 ppm
7 - day means					
(Kitchen)	NO_2	5	0.26 ppm	5	0.04 ppm
(Bedroom)	NO_2	4	0.02 ppm	4	0.04 ppm
(Kitchen)	HCHO	5	0.33 ppm	4	0.04 ppm
(Bedroom)	HCHO	4	0.04 ppm	4	0.13 ppm
India c. Eight Gujarat Villages (3 stoves)	CO	36	110 ppm	48	34 ppm
One stove type (4 villages)	CO	27	120 ppm	30	43 ppm
d. One Haryana village (f)	CO	51	7 ppm	36	6 ppm

Location	Pollutant	Traditional Stove: No. of expts	Traditional Stove: Mean	Improved Stove: No. of expts	Improved Stove: Mean
d. One Karnataka village (f,g)	CO	24	23 ppm	39	9 ppm
Simulated cooking (with area monitoring)					
e. Nepal Kathmandu Valley	CO	16	600 ppm	28	400 ppm
		All new stoves		Well-installed new stoves	
	CO	28	400 ppm	11	100 ppm

* Except where noted, all measurement were taken during the cooking period in the dry season either by use of personal monitoring equipment worn by the cook or with stationary monitors placed nearby. TSP = total suspended particulates; BaP = bezo(a)pyrane; CO = carbon monoxide; NO_2 = nitrogen dioxide; HCHO = formaldehyde.

a. Source: H. Reid, K.R. Smith, and B. Sherchand, "Indoor samke EXposures from Traditional and Improved Cookstoves: Comparisons Among Rural Nepali Women, " Mountain Research and Development 6(4), 1986, pp 293-294.

b. Source: K.R. Smith, Biofuels, Air Pollution, and Health: A Global Review, Plenum Publishing Company New York City, 1987.

c. Source: K.R. Smith and M.B. Durgaprasad, "Difficulties in Achieving and Verifying Exposure Reductions in Village Househoulds with Improved Biofuel-fired Cookstoves", in B. Seifert et al. (eds) Indoor Air'87 Institute for Water, Soil, and Air Hygiene, Berlin, 3, 1987, pp 115-120.

d. Source: J. Ramakrishna, "Cultural, Technological, and Enviromental Factors Influencing Indoor Air Pollution in Rural India," in B. Seifert et al.(eds) Indoor Air '87, Institute for Water, Soil, and Air Hygiene, Berlin, 3, 1987, pp 34-39.

e. S. Joseph et al, "A Preliminary Investigation into the Impact on Pollution Levels in Nepali Household by the Introduction of Chimney Stoves," Food and Agricultutal Organization, Kathmandu, 1985.

f. These measurements were taken in all three major seasons (summer, winter, monsoon).

g. Also measured were exposures of women cooking with traditional stoves placed under a fireplace-style hood. With 24 measurements, the means were 1.6 mg/cu.m (TSP) and 5 ppm (CO), which are significantly lower than both traditional stoves and, for TSP, the improved stove in the same villages.

VI.2 National Ambient Air Quality Standards (NAAQS)

Faced with growing air pollution problems, a number of countries have established ambient air quality standards for certain critical pollutants, over the last fifteen years. As the knowledge base about adverse health effects at low levels of pollution -- or about threshold levels below which there are no detectable effects -- is poor, administrators have had considerable leeway within which to set such standards. In general, it is not possible to compare these standards across nations, because of differences in averaging times specified for maximum allowable concentrations. However, an attempt is made to compare India's national air quality standards with those of other countries.

India is the only country which has set standards for an averaging time period of eight hours, uniformly for all critical pollutants. For purposes of establishing NAAQS, the Government has classified the country into three distinct areas : A, B and C. The standards are most lenient for areas classified as A (such as wastelands); and most stringent for areas classified as C (such as certain cities). However, it is not clear whether the established standards for ambient air quality can be enforced, as only a few cities have air quality monitoring stations.

Table VI.2.1 gives the NAAQS for carbon monoxide (CO). The effects of CO poisoning are well known; and NAAQS for CO are generally set lower than what may be considered safe for normal healthy adults. However, it is important to realize that these standards may not be considered safe for patients with heart diseases (angina), hemolytic anemia, people living at high altitudes etc. Comparing the eight-hour standards between various countries, it appears that : (i) the French standard is too high, and may not provide an adequate safety margin; and (ii) the standards in India and the east-European countries are too stringent.

Standards for total suspended particulates (TSP) are given in Table VI.2.2. Most countries have set standards for TSP (i.e., including all particles to a size of 100 microns), although inhalable particles (less than 10 microns), and respirable particles (less than 3 microns) are more relevant from the public health point of view. As larger particles normally dominate measurements, it is not clear whether the NAAQS for TSP are directly relevant from the point of view of public health -- China has set a different standard for inhalable particles. However, it may be noted that the variability of standards for TSP is much less than that for CO.

Standards for sulphur oxides are shown in Table VI.2.3. Sulphur oxides have significant effects on materials, vegetation and human health, and much attention has been paid to control them. The NAAQS standards however, have been set in most countries largely in view of public health effects.

NAAQS for nitrogen oxides are shown in Table VI.2.4. The major environmental implication of nitrogen oxides has been identified as acidification of precipitation. As for CO, the NAAQS for nitrogen oxides also show a high degree of variability.

Table VI.2.1 : National Ambient Air Quality Standards For Carbon Monoxide(mg/cu.m.)

	Country	Averaging Time (hours)			
		0.5	1	8	24
1.	India Area A	-	-	5.0	-
2.	India Area B	-	-	2.0	-
3.	India Area C	-	-	1.0	-
4.	Austria	-	38.9	10.3	-
5.	Bulgaria	3.0	-	-	1.0
6.	Canada (Desirable)	-	15.0	6.0	-
7.	Canada (Acceptable)	-	35.0	15.0	-
8.	China (Class I&II)	10.0*	-	-	4.0
9.	China (Class III)	20.0*	-	-	6.0
10.	Czechoslovakia	6.0	-	-	1.0
11.	Finland	-	40.0	10.0	-
12.	France	114.5*	-	57.3	-
13.	F.R.G.	-	40.0	10.0	-
14.	Israel	35.0	-	11.5	-
15.	Italy	57.2	-	22.5	-
16.	Japan	-	-	23.0	11.5
17.	Philippines	-	33.0	10.0	-
18.	Rumania	6.0	-	-	2.0
19.	U.S.A.	-	40.0	10.0	-
20.	U.S.S.R.	3.0	-	-	1.0
21.	Yugoslavia	3.0	-	-	1.0

* Maximum value allowed at any time.

Source : Dilip R. Ahuja, "National Ambient Air Quality Standards and Averaging Times" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

Table VI.2.2 : National Ambient Air Quality Standards For Suspended Particulates (mg/cu.m.)

Country	Averaging Time (hours) 0.5	1	2	8	24	4380	8760
1. India Area A	-	-	-	0.5	-	-	-
2. India Area B	-	-	-	0.2	-	-	-
3. India Area C	-	-	-	0.1	-	-	-
4. Austria Zone I	-	-	-	-	0.12	-	-
5. Austria Zone II	-	-	-	-	0.20	-	-
6. Canada (Acceptable)	-	-	-	-	0.12	-	0.06
7. Canada (Tolerable)	-	-	-	-	0.40	-	-
8. China Class I	0.3*	-	-	-	0.15	-	-
9. China Class II	1.0*	-	-	-	0.30	-	-
10. China Class III	1.5*	-	-	-	0.50	-	-
11. Finland	-	-	-	-	0.15	-	0.08
12. France	-	-	-	-	0.15	-	-
13. F.R.G.	-	0.48	-	-	0.15	-	-
14. Hungary	-	-	-	-	0.20	-	-
15. Israel	-	-	-	-	0.20	-	0.075
16. Italy	-	-	0.75	-	0.30	-	-
17. Japan	-	0.20	-	-	0.10	-	-
18. Norway	-	-	-	-	0.15	0.06	-
19. Philippines	-	-	-	-	0.25	-	0.18
20. Rumania	0.5	-	-	-	0.15	-	-
21. Sweden	-	0.10	-	-	-	-	-
22. U.S.A. (Primary)	-	-	-	-	0.26	-	0.075
23. U.S.A. (Secondary)	-	-	-	-	0.15	-	0.06
24. U.S.S.R.	0.5	-	-	-	0.15	-	-
25. Yugoslavia	-	-	-	-	-	-	-

* Maximum value allowed at any time.

Source : Dilip R. Ahuja, op cit Ref. Table VI.2.1.

Table VI.2.3 : National Ambient Air Quality Standards For Sulphur Oxides (mg/cu.m.)

Country	Averaging Time (hours)					
	0.5	1	8	24	4380	8760
1. India Area A	-	-	0.12	-	-	-
2. India Area B	-	-	0.08	-	-	-
3. India Area C	-	-	0.03	-	-	-
4. Austria Zone I	0.15	-	-	0.10	-	-
5. Austria Zone II	0.30	-	-	0.30	-	-
6. Bulgaria	0.50	-	-	0.05	-	-
7. Canada (Desirable)	-	0.45	-	0.15	-	0.03
8. Canada (Acceptable)	-	0.90	-	0.30	-	0.06
9. China ClassI	0.15*	-	-	0.05	-	0.02
10. China ClassII	0.50*	-	-	0.15	-	0.06
11. China Class III	0.70*	-	-	0.25	-	0.10
12. Czechoslavakia	0.50	-	-	0.15	-	-
13. Finland	-	-	-	0.30	-	0.07
14. France	-	-	-	0.25	-	-
15. F.R.G.	-	0.40	-	0.14	-	-
16. Hungary	0.50	-	-	0.15	-	-
17. Israel	0.75	-	-	0.26	-	-
18. Italy	0.75	-	-	0.38	-	-
19. Japan	-	0.26	-	0.10	-	-
20. Norway	-	0.40	-	0.20	0.06	-
21. Rumania	0.75	-	-	0.25	-	-
22. Sweden	-	0.625	-	0.25	-	-
23. U.S.A. (Primary)	-	-	-	0.365	-	0.08
24. U.S.A. (Secondary)	-	1.30	-	-	-	-
25. U.S.S.R.	0.50	-	-	0.05	-	-
26. Yugoslavia	0.50	-	-	0.15	-	-

* Maximum value allowed at any time.

Source : Dilip R. Ahuja, op cit Ref. Table VI.2.1.

Table VI.2.4. : National Ambient Air Quality Standards For Nitrogen Oxides (mg/cu.m.)

Country	Averaging Time (hours)					
	0.5	1	8	24	4380	8760
1. India Area A	-	-	0.12	-	-	-
2. India Area B	-	-	0.08	-	-	-
3. India Area C	-	-	0.03	-	-	-
4. Bulgaria	0.085	-	-	0.085	-	-
5. Canada A	0.4	-	-	0.2	-	-
6. China Class I	0.1*	-	-	0.05	-	-
7. China Class II	0.15*	-	-	0.1	-	-
8. China Class III	0.3*	-	-	0.15	-	-
9. Finland	-	0.5	-	0.2	-	-
10. France	-	-	-	0.2	-	-
11. F.R.G.	-	1.0	-	-	-	-
12. Hungary Zone I	0.15	-	-	0.05	-	-
13. Hungary Zone II	0.5	-	-	0.15	-	-
14. Israel	1.0	-	-	0.6	-	-
15. Italy	0.6	-	-	0.2	-	-
16. Japan	-	-	-	0.1	-	-
17. Norway	-	0.4	-	0.2	0.1	-
18. Rumania	0.3	-	-	0.1	-	-
19. U.S.A.	-	-	-	-	-	0.1
20. U.S.S.R.	0.085	-	-	0.085	-	-
21. Yugoslavia	0.085	-	-	0.085	-	-

* Maximum value allowed at any time.

Source : Dilip R. Ahuja, op cit Ref. Table VI.2.1.

Table VI.2.5. : Ambient Air Quality Monitoring Stations in India

City	State	No. of Monitoring Stations
Agra	Uttar Pradesh	5
Anpara	Uttar Pradesh	3
Delhi	-	5
Haldia	West Bengal	3
Howrah	West Bengal	5
Kota	Rajasthan	3
Surat	Gujarat	3
Total		27

Source : Ministry of Environment and Forests, Department of Environment, G.O.I., Annual Report, 1984-85.

VI.3 Emission Standards for Indian Industry

Concern over pollution caused by industries has increased during recent years in India. The Department of Environment (GOI) has undertaken certain steps to check industrial pollution, which include : (i) an environmental impact assessment of development projects; and (ii) the establishment of emission standards for various industries. The emission standards are expressed as concentration of pollutants per unit volume of air under normal conditions (i.e. 25 °C, 760 mm Hg pressure and 0% moisture).

The Central Board for the Prevention and Control of Water Pollution (CBPCWP), New Delhi, has prescribed emission standards for certain industries, within the framework of the Air (Prevention and Control of Pollution) Act, 1981. The prescribed standards are supposed to be reviewed from time to time, and may be revised taking into account the actual experience and monitoring data available. State Boards may adopt standards that are more stringent than those laid down by the Central Board, but they can not relax those standards. Standards prescribed for some of the industries are given below.

Standards are prescribed only for the most critical pollutants. They are mostly particulate matter, such as in the thermal power stations, iron and steel plants, cement plants and fertilizer plants. As sulphur-dioxide emissions are most critical in oil refineries, suitable standards are prescribed there. For other industries, the method prescribed for keeping sulphur-dioxide concentrations at ground level within reasonable limits, is to raise stack heights appropriately.

Table VI.3.1 : Thermal Power Stations -- Emission Standards for Particulate Matter (mg/Ncu.m.)*

Boiler Size	Protected Areas	Other Areas**	
		Old	New
< 200 MW	150	600	350
> = 200 MW	150	-	150

* mg/normal cu.m. of flue gases.

** Electrostatic precipitators (ESP) help in the removal of particulate matter. BHEL came out with an improved ESP design in 1979. Therefore, all plants commissioned after Dec. 31, 1979 are classified as new plants.

Table VI.3.2 : Integrated Iron and Steel Plants -- Emission limits for Particulate Matter (mg/Ncu.m.)

Process	Emission Limits
a. Sintering plant	150
b. Coke Oven	-
c. Blast furnace	-
d. Steel making	
- during normal operation	150
- during oxygen lancing	400

b,c : No limit.

Table VI.3.3 : Cement Plants - Emission Standards for Particulate Matter (mg/Ncu.m.)

Capacity	Prospected Area	Other Areas
= < 200 tonnes/day	250	400
> 200 tonnes/day	150	250

VI.3.4 : Fertilizer Plants - Emission Limits for Particulate Matter and Fluorides

Product	Process	Pollutant	Emission limit (mg/Ncu.m.)
a. Urea	Prilling Tower	Particulate	50
b. Phosphatics	Acidification of rock phosphate	Fluorides	25
c. Phosphatics	Granulation, and Grinding	Particulates	150

Table VI.3.5 : Oil Refineries - Emission Standards for Sulphur Dioxide

Process	SO_2 Emission Limit
a. Atmospheric and Vacuum Distillation	0.25 kg/tonne of feed
b. Catalytic cracker	2.5 kg/tonne of feed
c. Sulphur recovery unit	120 kg/tonne of sulphur in the feed

Table VI.3.6. : Guidelines for Minimum Stack Height

Type of Plant	Pollutant	Minimum Stack Height (metres)*
a. Thermal Power Stations		
a1 < 200 MW	Sulphur dioxide	$14\ Q^{0.3}$ where Q=SO_2 emission in kg/hr.
a2 200 - 500 MW	" "	220
a3 > = 500 MW	" "	275
b. Other Industrial Plants	" "	> = 30
c. All Industrial Plants	Particulate matter	$74\ Q^{0.27}$ where Q= particulate emission in tonnes/hr

* Stack height given by the expressions for a.1 and c valid as long as it is over 30 metres.

VII. ENERGY UNITS AND CONVERSION FACTORS

Until now, energy data in India have been compiled in coal replacement units, as opposed to coal equivalent units or other units that measure the calorific content of an energy source. By using coal replacement units, one effectively compiles data on the useful energy consumed. The conversion of energy demand data into replacement units is a two-step process: (i) measuring useful energy per unit of a particular fuel in a particular end-use; and (ii) estimating the quantity of coal required to obtain the same amount of useful energy in the same end-use.

For example, consider a fuel f, of energy content x kCal/kg, used with an efficiency ef in a particular end use. To find the coal replacement value, let coal of energy content 5000 kCal/kg be used with efficiency ec in the same end use. The coal replacement can be worked out as follows:

Useful energy in kCal from 1 kg of fuel f= ef.x

Useful energy in kCal from 1 kg of coal = ec.5000

$$\text{Coal replacement unit for fuel f} = \frac{ef.x}{ec.5000} \text{ kg of coal}$$

Although the coal replacement concept is of relevance to India, where coal is the major energy source, conversion of data into coal replacement units entails some problems. It is necessary to know the end-use efficiency of each end-use device or equipment using a particular fuel, as well as an estimate of the efficiency of a device (sometimes hypothetical, as in case of automobiles using gasoline or diesel) if it were to use coal for the same end-use. Furthermore, it would be necessary to differentiate between different end-uses of various energy fuels (e.g. kerosene for lighting and cooking). Clearly, the latter has seldom been done while computing coal replacement values. And it is difficult to get even estimates of overall average efficiencies of the various end-use equipment.

However, some estimates of coal replacement units for various fuels are presented. The calorific contents for several commercial and traditional fuels are also presented.

A problem which often confronts energy analysts relates to the attribution of a calorific value to electricity. The calorific equivalent of electricity may be measured in one of the following two ways:

(i) By equating it to the calorific content of the amount of fossil fuel that is required to generate 1 kWh of electricity in conventional thermal power stations; or

(ii) By equating it to the amount of fossil fuel that has the same energy content as the theoretical maximum heating value of 1 kWh of electricity.

The results obtained from the two methods are very different; this difference reflects the fact that two-thirds or more of the energy content of the primary fossil fuel input for thermal power generation gets lost as waste heat during conversion. To generate 1 kWh of electricity with a maximum theoretical heating value of 860 kCal, even the most efficient thermal stations would require fossil fuel with an energy content of 2500 kCal/kg.

There is no theoretically correct answer regarding the choice between the two methods -- the choice in fact, depends on the purpose for which the data are used. For instance, if the issue in question relates to the investigation on the options for development of thermal or hydro-electric projects, the first method is suitable.

Table VII.1: Coal Replacement Units

Soft-coke/Coal		1 MMT = 1.5 mtcr
Kerosene	- for lighting	1 million Kilolitres = 2.086 mtcr
	- for cooking	1 million Kilotitres = 5.623 mtcr
LPG		1 MMT = 10.184 mtcr
Electricity		1000 GWh = 0.706 mtcr
Firewood		1 MMT = 0.655 mtcr
Charcoal		1 MMT = 1.807 mtcr
Dungcakes		1 MMT = 0.301 mtcr
Crop Residues		1 MMT = 0.527 mtcr

Source: NCAER, Domestic Fuel Survey With Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table VII.2: Calorific Value of Different Fuels

a. Commercial Fuels	
a1 Coal	
Hard Coal	5000 kCal/kg
Lignite Brown Coal	2310 kCal/kg
Charcoal	6900 kCal/kg
a2 Petroleum Products	
LPG	10800 kCal/kg
Gasoline/Naphtha	10500 kCal/kg
Kerosene	10300 kCal/kg
Jet Fuel	10400 kCal/kg
Diesel Oil/Automotive Diesel	10200 kCal/kg
Fuel Oil	9600 - 9900 kCal/kg
a3 Electricity	860 kCal/kWh
b. Biomass	
b1 Agricultural Wastes	
Paddy Straw	3000 kCal/kg
Rice Husk	3440 kCal/kg
Mango Leaves	3390 kCal/kg
Groundnut Straw	4200 kCal/kg
Sugarcane Bagasse	3800 kCal/kg
Wheat Straw	3800 kCal/kg
Cotton Stalks	3300 kCal/kg
Maize Stalks	4700 kCal/kg
Maize Cobs	3500 kCal/kg
Bajra Stalks	3850 kCal/kg
Gram Straw	3950 kCal/kg
Masoor Straw	3810 kCal/kg
Moong Straw	3980 kCal/kg
b2 Forestry Residues	
Wood Wastes	2500 -3850 kCal/kg
Bark	2500 - 2850 kCal/kg
b3 Animal Wastes	
Cowdung	3290 kCal/kg
Cowdung Cake	3140 kCal/kg

a1. Gross calorific value of coal; the useful heating values for various grades of coal are given in section II.1.
a2. Net Calorific value.
b. Upper Heating value; for oven dried biomass.

Source: (i) Department of Petroleum, Indian Petroleum & Natural Gas Statistics 1985-86; (ii) The World Bank, Guidelines for the Presentation of Energy Data in Bank Reports, Energy Department Paper No. 7, October 1982; and (iii) O.P. Vimal & P.D. Tyagi, Energy From Biomass, Agricole Publishing Academy, New Delhi, 1984.